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## Field selection of lemon hybrids for tristeza virus resistance

### Seleção a campo de híbridos de limoeiros para resistência à tristeza

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#### Abstract

In Brazil, there is a low diversification of the citrus species used, which makes crops very vulnerable to diseases. As the *Citrus tristeza virus* (CTV) is endemic in Brazil, it is possible to select CTV-resistant hybrid varieties for its control. In this work, we evaluated the reaction of lemon trees and their hybrids to natural infection by CTV isolates in Cruz das Almas, in the Reconcavo Baiano region. Volkamerian lemon tree (VKLT), Cravo lemon tree (CLT), Palm orange tree (POT), Valencia orange tree (VOT), Sunki mandarin tree (SMT), Swingle citrumelo tree (SCT) and Trifoliolate orange tree (TOT) were used as parents. VKLT x CLT, VKLT x POT, VKLT x VOT, SMT x (CLT x TOT) and CLT x SCT hybrids were produced. These were kept in the field, being evaluated as for stem pitting intensity when aged between four and seven years. The crosses that provided a higher percentage of CTV-resistant hybrids were CLT x SCT, VKLT x CLT and SMT x (CLT x TOT). On the other hand, the crosses between VKLT and POT, VKLT and VOT showed a higher percentage of susceptible hybrids. In this work, CTV-resistant lemon hybrids were generated. The information will allow to direct new crosses of lemon, aiming to obtain hybrids with a higher level of tristeza resistance.

**Additional keywords:** breeding; citrus; *Citrus tristeza virus*; CTV.

#### Resumo

No Brasil há uma baixa diversificação das espécies de citros utilizadas, o que torna os plantios muito vulneráveis às doenças. Como o vírus da tristeza do citros (*Citrus tristeza virus*, CTV) é endêmico no Brasil, para o seu controle podem ser selecionadas variedades ou híbridos com resistência para o CTV. Neste trabalho avaliou-se a reação de limoeiros e seus híbridos à infecção natural por isolados do CTV em Cruz das Almas no Recôncavo Baiano. Foram utilizados como parentais o limoeiro 'Volkameriano' comum (LVKC), do limoeiro 'Cravo' comum (LCRC), da laranja 'Palmeiras' (LPA), da laranja 'Valência' (LVA), da tangerineira 'Sunki' (TSKC), do citrumelo 'Swingle' (CTSW) e de *Poncirus trifoliata* (TR). Foram produzidos híbridos de LVKC x LCRC, LVKC x LPA, LVKC x LVA, TSKC x (LCRC x TR) and LCRC x CTSW. Os híbridos foram mantidos em campo e avaliados com idade entre quatro e sete anos, quanto a intensidade de caneluras presentes. Os cruzamentos que propiciaram a obtenção de uma maior porcentagem de híbridos com resistência para o CTV foram LCRC x CTSW, LVKC x LCRC e TSKC x (LCCR x TR). Já os cruzamentos entre LVKC x LPA, LVKC x LVA apresentaram uma porcentagem mais alta de híbridos suscetíveis. Nesse trabalho foram gerados híbridos de limoeiro com resistência para CTV. As informações obtidas permitirão direcionar novos cruzamentos de limoeiros visando à obtenção de híbridos com um nível maior de resistência para tristeza.

**Palavras-chave adicionais:** citros; *Citrus tristeza virus*; CTV; melhoramento.

#### Introduction

Brazil produces 1.1 million tons of lemon annually, Bahia being the third largest producer in the country (IBGE, 2014).

Globally, citriculture presents a greater diversification, both in cultivated species (sweet orange, lemon, mandarin and grapefruit) and among the sweet orange (*Citrus sinensis* (L.) Osbeck) varieties produced (Mattos Júnior et al., 2005). In Brazil, citriculture uses the combination 'Pera' orange (*C. sinensis*) tree with 'Cravo' lemon (*C. limonia* Osbeck) rootstock in large scale (Soares Filho et al., 1997). This narrow genetic

base makes crops very vulnerable, particularly to pests. Due mainly to the occurrence of diseases, other rootstocks have been used in recent years, such as 'Cleopatra' mandarin (*C. reshni* hort. Ex Tanaka), 'Swingle' citrumelo [*C. paradisi* Macfad. x *Poncirus trifoliata* (L.) Raf.] and 'Sunki' mandarin [*C. Sunki* (Hayata) hort. ex Tanaka] (Mattos Júnior et al., 2005). The genus *Citrus* (L.) and other related ones have a significant genetic variability, which can be exploited in citrus breeding programs in the generation of new varieties and rootstocks better suited to the tropics (Soares Filho et al., 1997).

In recent years, the main rootstocks used in Brazil have been 'Cravo' lemon, 'Cleopatra' mandarin,

'Volkamerian' lemon (*C. volkameriana* V. Ten. & Pasq.), 'Swingle' citrumelo, 'Sunki' mandarin and trifoliolate orange (*P. trifoliata*), with predominance of the 'Cravo' lemon. Trifoliolate orange is immune to *Citrus tristeza virus* (CTV) and 'Cravo', 'Cleopatra', 'Volkamerian', 'Swingle' and 'Sunki' are resistant (Mattos Júnior et al., 2005).

Diseases caused by viruses, viroids, and the like are among the most damaging to citrus fruits. CTV is one of the viruses of major economic importance. It caused the loss of about 100 million plants and the replacement of sour orange (*C. aurantium* L.) rootstock (Moreno et al., 2008).

CTV belongs to the genus *Closterovirus*, family *Closteroviridae* (King et al., 2012). It has filamentous particles, single-stranded RNA, a coat protein of 25 kDa and another of 27 kDa, being transmitted in a non-circulatory manner by *Toxoptera citricidus* Kirk. The tristeza virus can infect most citrus species (Moreno et al., 2008).

The symptoms of tristeza depend on the strain present and the canopy/rootstock combination affected (Moreno et al., 2008; Mattos Júnior et al., 2005). In canopies cultivated on tolerant rootstocks, the CTV can produce stem pitting, atrophy, leaves with reduced size, and little fruits with thick albedo, low juice content and high acidity (Mattos Júnior et al., 2005).

Sour orange, grapefruit (*C. paradisi*) and 'Persian' lime (*C. limettioides* Tanaka) are susceptible to CTV. On the other hand, 'Cravo' lemon, 'Cleopatra' and 'Sunki' mandarins, citrumelos and 'Volkamerian' lemon are tolerant to the virus. Trifoliolate oranges are immune to the CTV (Mattos Júnior et al., 2005).

Some authors have correlated the greater virulence of strains with stem pitting in branches and trunks. Thus, Salibe et al. (1992) and Meissner Filho et al. (2002) elaborated grade scales, using stem pitting intensity presented, for the selection of strains with less virulence and plants better adapted to certain regions. The scale elaborated by Meissner Filho et al. (2002) has illustrations, making it more didactic.

In Brazil, CTV and the vector are endemic. Therefore, the best alternative to control tristeza is the use of varieties with some level of resistance or pre-immunized with weak strains of the virus (Moreno et al., 2008; Müller, 1987).

In this work, we evaluated the reaction of lemon trees and their hybrids to a natural infection by CTV isolates in Cruz das Almas, in the Reconcavo Baiano region.

## Material and methods

The experiments were carried out in the Citrus Germplasm Active Bank (GAB) and in a field of hybrid seedlings bred by the Citrus Breeding Program (CBP), in the municipality of Cruz das Almas, Reconcavo Baiano, at an altitude of 225 m. The climate of the region is warm and humid tropical with annual average rainfall of 1,170 mm, annual average

temperature of 24.5 °C and relative humidity of 80% (Lima Filho et al., 2013).

The evaluated hybrids are from crosses made by the CBP and are being tested for use as rootstocks. 'Volkamerian' lemon tree (*C. volkameriana* V. Ten. & Pasq.) (VKLT), 'Cravo' lemon tree (CLT), 'Palmeiras' orange tree (*C. sinensis*) (POT), 'Valencia' orange tree (*C. sinensis*) (VOT), 'Sunki' mandarin tree [*C. Sunki* (Hayata) hort. (SMT)], 'Swingle' citrumelo tree (*C. paradisi* x *Poncirus trifoliata* (L.) Raf.) (SCT) and trifoliolate orange tree (*P. trifoliata*) (TOT) were used as parents. Hybrids were produced from the crosses VKLT x CLT, VKLT x POT, VKLT x VOT, SMT x (CLT x TOT) and CLT x SCT.

The hybrids were kept in the field and when they were aged between four and seven years, up to ten branches per plant were collected with a length of approximately 20 cm, covering all quadrants. Regarding the parents from the crosses performed, 10 branches of three plants were collected. The branches were autoclaved for ten minutes to facilitate bark removal, according to Meissner Filho et al. (2002).

Each plant represented a single genotype, coming from a single seed. Around the whole experimental area there were many plants of different citrus species.

The branches were evaluated according to stem pitting intensity, with the following grade scale: 1 - absence of stem pittings; 2 - sparse surface stem pitting; 3 - presence of surface stem pitting, with medium intensity; 4 - several surface stem pitting or presence of few deep stem pitting; and 5 - the entire surface of the branch covered by deep stem pitting or high-intensity surface stem pitting (Meissner Filho et al., 2002). The grades were given by three evaluators, obtaining an average grade for each genotype.

The grades obtained were transformed into a percentage, using the following formula:  $G (\%) = (Gx: TR) \times 100$ , where:  $G (\%)$  = percentage grade;  $Gx$  = total number of branches with grade  $x$ ;  $x$  = grades 1, 2, 3, 4 or 5;  $TR$  = total readings. The parents and their hybrids were then classified as to the reaction to tristeza virus in: Very Resistant (VR) - branches without stem pitting, grade 1; Resistant (R) - branches with grade 2; Susceptible (S) - branches with grade 3; Very Susceptible (VS) - branches with grade 4; Extremely Susceptible (ES) - branches with grade 5.

Since it is a categorical variable, the frequency was calculated, and the genotypes were classified according to their reaction, based on the highest percentage of each evaluated grade.

## Results and discussions

The parents used in the crosses 'Cravo' lemon tree and 'Volkamerian' lemon tree, 'Sunki' mandarin tree and 'Cravo' lemon tree x *P. trifoliata* hybrid (CLT x TOT) showed different reactions to the natural infection by local CTV isolates in the field (Tables 1 to 5).

**Table 1** - Reaction of the parental and hybrids of the common 'Cravo' (*Citrus limonia* Osbeck) with citrumelo [*C. paradisi* Macfad. x *Poncirus trifoliata* (L.) Raf.] 'Swingle' in relation to *Citrus tristeza virus* (CTV) in Cruz das Almas, Bahia, Brazil.

(1)Genotypes	(2)Note (%)					(3)TR	(4)Reaction
	1	2	3	4	5		
Hybrids							
CLT x SCT – 01	33.3	50.0	16.7	0.0	0.0	6	R
CLT x SCT – 02	100.0	0.0	0.0	0.0	0.0	6	VR
CLT x SCT – 03	100.0	0.0	0.0	0.0	0.0	6	VR
CLT x SCT – 04	73.3	26.7	0.0	0.0	0.0	15	VR
Average Parental	76.6	19.2	4.2	0.0	0.0	33	
CLT	98.9	1.1	0.0	0.0	0.0	90	VR
SCT	71.1	24.4	4.5	0.0	0.0	90	VR

(1) CLT = Common 'Cravo' lemon tree (*Citrus limonia* Osbeck) e SCT = citrumelo 'Swingle' [*C. paradisi* Macfad. x *Poncirus trifoliata* (L.) Raf.]. (2) Note 1 - absence of stem pitting; 2 - sparse surface stem pitting; 3 - presence of surface stem pitting, with medium intensity; 4 - several surface stem pitting or presence of few deep stem pitting; and 5 - the entire surface of the branch covered by deep stem pitting or high-intensity surface stem pitting. (3) TR = total of readings for each genotype evaluated. (4) R = Resistant, VR = Very Resistant.

**Table 2** - Reaction of the parental and hybrids of the common 'Volkameriano' lemon lime (*Citrus volkameriana* V. Ten. & Pasq.) with orange 'Valencia' [*C. sinensis* (L.) Osbeck] in relation to *Citrus tristeza virus* (CTV) in Cruz das Almas, Bahia, Brazil.

(1)Genotypes	(2)Note (%)					(3)TR	(4)Reaction
	1	2	3	4	5		
Hybrids							
VKLT x VOT – 01	51.9	33.3	14.8	0.0	0.0	27	VR
VKLT x VOT – 02	0.0	3.7	59.3	37.0	0.0	27	S
VKLT x VOT – 03	81.5	14.8	3.7	0.0	0.0	27	VR
VKLT x VOT – 05	37.0	55.6	7.4	0.0	0.0	27	R
VKLT x VOT – 06	28.6	42.9	28.6	0.0	0.0	21	R
VKLT x VOT – 07	66.7	22.2	11.1	0.0	0.0	27	VR
VKLT x VOT – 08	0.0	0.0	16.7	55.6	27.8	18	VS
VKLT x VOT – 09	3.7	11.1	29.6	11.1	44.5	27	ES
VKLT x VOT – 11	7.4	25.9	51.9	14.8	0.0	27	S
VKLT x VOT – 12	0.0	22.2	33.4	22.2	22.2	27	S
VKLT x VOT – 15	88.9	11.1	0.0	0.0	0.0	18	VR
VKLT x VOT – 39	96.3	3.7	0.0	0.0	0.0	27	VR
Average Parental	38.5	20.5	21.4	11.7	7.9	300	
VKLT	77.8	22.2	0.0	0.0	0.0	90	VR
LVA	73.3	24.5	2.2	0.0	0.0	90	VR

(1) VKLT = common 'Volkamerian' lemon tree (*Citrus volkameriana* V. Ten. & Pasq.), and VOT = 'Valência' orange tree [*C. sinensis* (L.) Osbeck]. (2) Note 1 - absence of stem pitting; 2 - sparse surface stem pitting; 3 - presence of surface stem pitting with medium intensity; 4 - several surface stem pitting or presence of few deep stem pitting; and 5 - the entire surface of the branch covered by deep stem pitting or high-intensity surface stem pitting. (3) TR = total of readings for each genotype evaluated. (4) VR = Very Resistant, R = Resistant, S = Susceptible, and ES = Extremely Susceptible.

'Cravo' lemon and 'Volkamerian' lemon trees received scores between one and two, being considered resistant to the CTV isolates present in the region (Table 1 and 2). The 'Cravo' lemon tree was prominent, presenting 98.9% of branches without stem pitting symptoms, and some of its hybrids with 'Swingle' citrumelo presented 100% of plants without symptoms (Table 1). Most of the 'Cravo' lemon x 'Swingle' citrumelo (CLT x SCT) hybrids were shown to be

resistant or very resistant to CTV. In experiments conducted in Sao Paulo by Pompeu Júnior & Blumer (2011), after six years of evaluation, no symptoms of tristeza were observed in these varieties. These two parents have been reported as tolerant to tristeza (Mattos Júnior et al., 2005). Santos Filho et al. (2000) observed that the 'Cravo' lemon tree, in combination with 'Pera' orange tree, showed symptoms of intense stem pitting only in its tissues in the presence of the

TSJ strain under greenhouse conditions, the same not occurring with the canopy cultivar. Nonetheless, in most situations, these lemon trees have shown CTV tolerance (Mattos Júnior et al., 2005).

'Volkamerian' lemon x 'Valencia' orange hybrids showed a different reaction to tristeza, with very resistant genotypes and extremely susceptible ones (Table 2). This behavior can be attributed to the susceptibility of the 'Valencia' orange tree. This orange tree has been cited as CTV-resistant, but Figueiredo et al. (1993) found differences in resistance among seven clones analyzed. Similar results were obtained by

Meissner Filho et al. (2002) in evaluations carried out in Cruz das Almas (BA).

'Volkamerian' lemon x Palm orange [*C. sinensis* (L.) Osbeck] (VKLT x POT) hybrids presented an intermediate level of resistance to tristeza (58.2%) (Table 3). The same conclusion was obtained by Meissner Filho et al. (2002) in evaluations carried out in previous years in the same region. The 'Volkamerian' lemon tree has been considered CTV-tolerant (Mattos Júnior et al., 2005).

**Table 3.** Reaction of the parental and hybrids of the common 'Volkamerian' lemon tree (*Citrus volkameriana* V. Ten. & Pasq.) x 'Palmeiras' orange tree [*C. sinensis* (L.) Osbeck] in relation to *Citrus tristeza virus* (CTV) in Cruz das Almas, Bahia, Brazil.

(1)Genotypes	(2)Note (%)					(3)TR	(4)Reaction
	1	2	3	4	5		
Hybrids							
VKLT x POT – 01	0.0	12.5	54.2	33.3	0.0	24	S
VKLT x POT – 04	66.7	22.2	11.1	0.0	0.0	18	VR
VKLT x POT – 07	81.0	9.5	9.5	0.0	0.0	21	VR
VKLT x POT – 08	40.7	59.3	0.0	0.0	0.0	27	R
VKLT x POT – 10	50.0	44.4	5.6	0.0	0.0	18	VR
VKLT x POT – 13	48.1	48.1	3.8	0.0	0.0	27	R
VKLT x POT – 15	44.5	48.1	7.4	0.0	0.0	27	R
VKLT x POT – 16	81.5	18.5	0.0	0.0	0.0	27	VR
VKLT x POT – 17	20.0	46.7	33.3	0.0	0.0	15	R
VKLT x POT – 20	85.7	14.3	0.0	0.0	0.0	21	VR
VKLT x POT – 21	59.4	37.0	3.7	0.0	0.0	27	VR
VKLT x POT – 24	100.0	0.0	0.0	0.0	0.0	15	VR
VKLT x POT – 25	0.0	0.0	3.7	77.9	18.5	27	VS
VKLT x POT – 27	41.7	58.3	0.0	0.0	0.0	12	R
VKLT x POT – 29	95.8	4.2	0.0	0.0	0.0	24	R
VKLT x POT – 31	100.0	0.0	0.0	0.0	0.0	21	VR
VKLT x POT – 32	40.7	44.5	14.8	0.0	0.0	27	VR
VKLT x POT – 34	94.4	5.6	0.0	0.0	0.0	18	VR
VKLT x POT – 36	72.2	22.2	5.6	0.0	0.0	18	VR
VKLT x POT – 37	28.6	38.1	28.6	4.7	0.0	21	R
VKLT x POT – 38	71.5	23.8	4.7	0.0	0.0	21	VR
Average Parental	58.2	26.5	8.9	5.5	0.8	456	
VKLT	77.8	22.2	0.0	0.0	0.0	90	VR
POT	83.4	12.3	3.3	0.0	0.0	90	VR

(1) VKLT = common 'Volkamerian' lemon tree (*Citrus volkameriana* V. Ten. & Pasq.), and POT = 'Palmeiras' orange tree [*C. sinensis* (L.) Osbeck]. (2) Note 1 - absence of stem pitting; 2 - sparse surface stem pitting; 3 - presence of surface stem pitting, with medium intensity; 4 - several surface stem pitting or presence of few deep stem pitting; and 5 - the entire surface of the branch covered by deep stem pitting or high-intensity surface stem pitting. (3) TR = total of readings for each genotype evaluated. (4) VR = Very Resistant, R = Resistant, S = Susceptible, and VS = Very Susceptible.

'Volkamerian' lemon x 'Cravo' lemon hybrids showed a good level of resistance to CTV (83%) (Table 4), these are virus-tolerant cultivars (Mattos Júnior

et al, 2005). Meissner Filho et al. (2002) obtained similar results in previous evaluations in Cruz das Almas, in the Reconcavo Baiano region.

**Table 4** - Reaction of the parental and hybrids of the common 'Volkamerian' lemon tree (*Citrus volkameriana* V. Ten. & Pasq.) x 'Cravo' common lemon (*C. limonia* Osbeck) in relation to *Citrus tristeza virus* (CTV) in Cruz das Almas, Bahia, Brazil.

(1)Genotypes	(2)Note (%)					(3)TR	(4)Reaction
	1	2	3	4	5		
Hybrids							
VKLT x CLT – 01	81.5	18.5	0.0	0.0	0.0	27	VR
VKLT x CLT – 03	100.0	0.0	0.0	0.0	0.0	9	VR
VKLT x CLT – 06	100.0	0.0	0.0	0.0	0.0	27	VR
VKLT x CLT – 08	91.7	8.3	0.0	0.0	0.0	12	VR
VKLT x CLT – 09	60.0	40.0	0.0	0.0	0.0	15	VR
VKLT x CLT – 10	70.8	29.2	0.0	0.0	0.0	24	VR
VKLT x CLT – 13	94.4	5.6	0.0	0.0	0.0	18	VR
VKLT x CLT – 15	100.0	0.0	0.0	0.0	0.0	12	VR
VKLT x CLT – 16	100.0	0.0	0.0	0.0	0.0	27	VR
VKLT x CLT – 17	92.6	7.4	0.0	0.0	0.0	27	VR
VKLT x CLT – 18	29.1	66.7	4.2	0.0	0.0	24	R
VKLT x CLT – 19	100.0	0.0	0.0	0.0	0.0	9	VR
VKLT x CLT – 21	96.3	3.7	0.0	0.0	0.0	27	VR
VKLT x CLT – 22	100.0	0.0	0.0	0.0	0.0	9	VR
VKLT x CLT – 24	90.5	9.5	0.0	0.0	0.0	21	VR
VKLT x CLT – 26	88.9	11.1	0.0	0.0	0.0	27	VR
VKLT x CLT – 30	88.9	11.1	0.0	0.0	0.0	27	VR
VKLT x CLT – 31	85.2	14.8	0.0	0.0	0.0	27	VR
VKLT x CLT – 34	88.9	11.1	0.0	0.0	0.0	27	VR
VKLT x CLT – 38	70.0	30.0	0.0	0.0	0.0	30	VR
VKLT x CLT – 39	61.1	38.9	0.0	0.0	0.0	18	VR
VKLT x CLT – 45	66.7	33.3	0.0	0.0	0.0	27	VR
VKLT x CLT – 47	61.1	38.9	0.0	0.0	0.0	18	VR
VKLT x CLT – 48	95.8	4.2	0.0	0.0	0.0	24	VR
VKLT x CLT – 49	52.4	47.6	0.0	0.0	0.0	21	VR
VKLT x CLT – 50	66.7	33.3	0.0	0.0	0.0	6	VR
VKLT x CLT – 52	83.3	16.7	0.0	0.0	0.0	12	VR
VKLT x CLT – 59	85.2	14.8	0.0	0.0	0.0	27	VR
VKLT x CLT – 61	93.3	6.7	0.0	0.0	0.0	15	VR
VKLT x CLT – 69	94.4	5.6	0.0	0.0	0.0	18	VR
VKLT x CLT – 74	83.3	16.7	0.0	0.0	0.0	12	VR
Average Parental	83.0	16.9	0.1	0.0	0.0	705	VR
VKLT	77.8	22.2	0.0	0.0	0.0	90	VR
CLT	98.9	1.1	0.0	0.0	0.0	90	VR

(1) VKLT = common 'Volkamerian' lemon tree (*Citrus volkameriana* V. Ten. & Pasq.) and CLT = 'Cravo' common lemon (*C. limonia* Osbeck)]. (2) Note 1 - absence of flutes; 2 - sparse surface stem pitting; 3 - presence of surface stem pitting, with medium intensity; 4 - several surface stem pitting or presence of few deep stem pitting; and 5 - the entire surface of the branch covered by deep stem pitting or high-intensity surface stem pitting. (3) TR = total of readings for each genotype evaluated. (4) VR = Very Resistant, and R = Resistant.

The hybrids of 'Sunki' mandarin with 'Cravo' lemon x *P. trifoliata* showed a good level of resistance to tristeza (61.2%) (Table 5). When analyzing the occurrence of tristeza stem pitting in citrus varieties, Figueiredo et al. (1993) found that most of the orange,

mandarin and true lemon (*C. limon* (L.) Burm.) trees are tristeza-resistant, whereas most of the lime and grapefruit trees are not. The good response of almost all SMT x (CLT x TOT) hybrids is due to the fact that both parents have some resistance to CTV. 'Sunki'

mandarin is CTV-tolerant and *P. trifoliata* is immune (Mattos Júnior et al., 2005). In this regard, Meissner Filho et al. (2002), analyzing citrus progenies, verified that 'Cravo' lemon x 'Sunki' mandarin hybrids behaved with a good level of resistance to tristeza. In New

Zealand, CTV strains that infect *P. trifoliata* and its hybrids have been detected (Harper et al., 2010). In evaluations made in Sao Paulo with trifoliolate orange hybrids, Pompeu Júnior & Blumer (2014) did not detect symptoms of CTV.

**Table 5** - Reaction of the parental and hybrid of the 'Sunki' mandarin tree [*Citrus sunki* (Hayata) hort. (TSKC) x 'Cravo' common lemon (*C. limonia* Osbeck)] (CLT) x *Poncirus trifoliata* (L.) Raf] (TOT), in relation to *Citrus tristeza virus* (CTV) in Cruz das Almas, Bahia, Brazil.

(1)Genotypes	(2)Note (%)					(3)TR	(4)Reaction
	1	2	3	4	5		
Hybrids							
SMT x (TOT x CLT) – 02	60.0	40.0	0.0	0.0	0.0	15	VR
SMT x (TOT x CLT) – 03	66.7	33.3	0.0	0.0	0.0	6	VR
SMT x (TOT x CLT) – 05	57.1	42.9	0.0	0.0	0.0	21	VR
SMT x (TOT x CLT) – 06	80.0	20.0	0.0	0.0	0.0	15	VR
SMT x (TOT x CLT) – 07	100.0	0.0	0.0	0.0	0.0	15	VR
SMT x (TOT x CLT) – 09	66.7	33.3	0.0	0.0	0.0	6	VR
SMT x (TOT x CLT) – 10	72.2	27.8	0.0	0.0	0.0	18	VR
SMT x (TOT x CLT) – 11	50.0	50.0	0.0	0.0	0.0	6	VR
SMT x (TOT x CLT) – 12	55.6	33.4	11.0	0.0	0.0	9	VR
Average Parental	61.2	31.2	1.2	0.0	0.0	111	VR
SMT	72.2	27.7	0.0	0.0	0.0	90	VR
TOT x CLT	68.9	28.9	2.2	0.0	0.0	90	VR

(1) SMT = 'Sunki' mandarin tree [*Citrus sunki* (Hayata)]; CLT = 'Cravo' common lemon (*C. limonia* Osbeck)]; TOT = *Poncirus trifoliata* (L.) Raf. (2) Note 1 - absence of flutes; 2 - sparse surface stem pitting; 3 - presence of surface stem pitting, with medium intensity; 4 - several surface stem pitting or presence of few deep stem pitting; and 5 - the entire surface of the branch covered by deep stem pitting or high-intensity surface stem pitting. (3) TR = total of readings for each genotype evaluated. (4) VR = Very Resistant.

Analyzing the reaction of somatic hybrids of *C. limoni*, *C. volkameriana*, *C. sunki* and *C. sinensis*, Mourão Filho et al. (2008) observed materials with a good level of resistance to tristeza.

Tristeza occurs in nature in the form of complexes consisting of different strains, in a state of greater or lesser equilibrium. In this context, genotypes with resistance reaction may be exhibiting this behavior because they are infected by weak strains of the tristeza virus, in such a balance that leads to a protection condition, determining a satisfactory development of the plant. As the inoculation is natural by the insect vector, there may be the transmission of only part of the strains of several existing complexes (Moreno et al., 2008).

Analyzing the reaction of citrus germplasms to CTV isolates in Sao Paulo, Carvalho et al. (1997) observed that the most virulent isolates occurred in sweet orange trees, whereas in true lemon trees and 'Cleopatra' mandarin tree (*C. reshni* hort. Ex Tanaka), the less virulent were dominant.

The crosses that provided a higher percentage of CTV-resistant hybrids, under field conditions in Cruz das Almas (BA), were: 'Cravo' lemon x 'Swingle' citrumelo, 'Volkamerian' lemon x 'Cravo' lemon and 'Sunki' mandarin x ('Cravo' lemon x *P. trifoliata*). Notwithstanding, the crosses between 'Volkamerian' lemon and Palm orange, 'Volkamerian' lemon and 'Valencia' orange showed a higher percentage of susceptible hybrids.

## Conclusion

Lemon hybrids with a good resistance level to *Citrus tristeza virus* were obtained in the conditions of Cruz das Almas, located in the Reconcavo Baiano region, Bahia, Brazil. The information generated will allow the targeting of new crosses of lemon trees, aiming to obtain hybrids with a higher level of resistance to citrus tristeza virus.

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