Série Pesquisa APTA

ISSN 1809 - 7944

Boletim Científico 14

Selected Citrus Rootstock Hybrids Introduced into the Germplasm Collection of the Instituto Agronômico

Rita BORDIGNON
Herculano Penna MEDINA FILHO
Walter José SIQUEIRA
Luís Alberto AMBRÓSIO
Armando CONAGIN
Rose Mary PIO
Jorgino POMPEU JUNIOR
Joaquim TEÓFILO SOBRINHO
Marcos Antonio MACHADO

Instituto Agronômico
Campinas - SP - Brasil
agosto/2007

Governo do Estado de São Paulo
Secretaria de Agricultura e Abastecimento
Agência Paulista de Tecnologia dos Agronegócios
Instituto Agronômico

Governador do Estado de São Paulo
José Serra

Secretário de Agricultura e Abastecimento
João de Almeida Sampaio Filho

Secretário-Adjunto
Antônio Júlio Junqueira de Queiroz

Chefe de Gabinete
Antonio Vagner Pereira

Coordenador da Agência Paulista de Tecnologia dos Agronegócios
João Paulo Feijão Teixeira

Diretor Técnico de Departamento do Instituto Agronômico
Orlando Melo de Castro

ISSN 1809-7944

SELECTED CITRUS ROOTSTOCK HYBRIDS INTRODUCED INTO THE GERMPLASM COLLECTION OF THE INSTITUTO AGRONÔMICO

Rita BORDIGNON
Herculano Penna MEDINA FILHO
Walter José SIQUEIRA
Luís Alberto AMBRÓSIO
Armando CONAGIN
Rose Mary PIO
Jorgino POMPEU JUNIOR
Joaquim TEÓFILO SOBRINHO
Marcos Antonio MACHADO

Boletim Científico IAC, Campinas, n. 14, 2007

Ficha elaborada pelo Núcleo de Informação e Documentação do Instituto Agronômico

S464 Selected citrus rootstock hybrids introduced into the germplasm collection of the Instituto Agronômico / Rita Bordignon; et al. Campinas: Instituto Agronômico, 2007. 36 p. (Série Pesquisa APTA. Boletim Científico, 14)

ISSN: 1809-7944 (online)

1. Citros - porta-enxertos 2. Citros - banco de dados de germoplasma - Instituto Agronômico I. Bordignon, Rita II. Medina Filho, Herculano Penna III. Siqueira, Walter José IV. Ambrósio, Luís Alberto V. Conagin, Armando VI. Pio, Rose Mary VII. Pompeu Júnior, Jorgino VIII. Teófilo Sobrinho, Joaquim IX. Machado, Marcos Antonio X. Título XI. Série

CDD 634.3

Instituto Agronômico
Centro de Comunicação e Transferência do Conhecimento
Avenida Barão de Itapura, 1.481
13020-902 Campinas (SP) - BRASIL
Fone: (19) 3231-5422 (PABX)
Fax: (19) 3231-4943
www.iac.sp.gov.br

EQUIPE PARTICIPANTE DESTA PUBLICAÇÃO

REVISÃO DE VERNÁCULO: MARIA ANGELA MANZI DA SILVA

COORDENAÇÃO DA EDITORAÇÃO: MARILZA RIBEIRO A. DE SOUZA

EDITORAÇÃO ELETRÔNICA: PRISCILA SIMIONATO BELAVENUTE E ADRIANO REDUCINO

CONTENTS

Page

ABSTRACT 1

RESUMO 2

1. INTRODUCTION 2

2. MATERIAL AND METHODS 3

3. RESULTS AND DISCUSSION 6

4. CONCLUSIONS 30

ACKNOWLEDGMENTS 31

REFERENCES 31

SELECTED CITRUS ROOTSTOCK HYBRIDS INTRODUCED INTO THE GERMPLASM COLLECTION OF THE INSTITUTO AGRONÔMICO (1)

Rita Bordignon(2);
Herculano Penna Medina Filho(2,7);
Walter José Siqueira(3);
Luís Alberto Ambrósio(4);
Armando Conagin(5);
Rose Mary Pio(6,7);
Jorgino Pompeu Junior(6,7);
Joaquim Teófilo Sobrinho(5);
Marcos Antonio Machado(6,7)

ABSTRACT

A genetic breeding program has been in progress since 1990 at the Instituto Agronômico de Campinas to develop, by hybridization and selection, rootstocks that associate favorable traits of the commercial clones Trifoliata orange 'Davis A' (*Poncirus trifoliata*) (T), Sunki mandarin '200' (*Citrus sunki*) (S), Rangpur lime 'Limeira' (*Citrus limonia*) (C) and Sour orange 'São Paulo' (*Citrus aurantium*) (A). This study investigated these parents represented by 138 nucellar clones and 534 hybrids of them identified by seven isoenzymatic and two morphological markers, forming seven groups of crosses (TxS, SxT, SxC, SxA, CxA, TxA and CxS). Parents and hybrids bud grafted with Valencia orange were studied for the yield of the first seven harvests, plant traits at eight years of age and the implications on productivity per area, crop efficiency of canopy, volume and theoretical tonnage. Preliminary tests were carried out to ascertain the induced industrial quality on the canopy. Fruits and seeds traits and descendents of some hybrids were observed. Tolerance to citrus tristeza virus (CTV), trunk gummosis and *Phytophthora* root rot were also considered for selection purposes. Based on the existence of genetic variability visually observed and detected by genetic parameters and taking as reference the confidence interval of the mean of the T, S and C parents with t at 95% probability, the potential of the different genotypes was

(1) Received for publication in December 12, 2005 and accepted in October 25, 2006.

(2) Centro de Café Alcides Carvalho, Instituto Agronômico (IAC), Caixa Postal 28, 13012-970 Campinas (SP). E-mail rita@iac.sp.gov.br, medina@iac.sp.gov.br.

(3) Centro de Genética, Instituto Agronômico (IAC), Caixa Postal 28, 13012-970 Campinas (SP).

(4) Laboratório de Geoprocessamento – Centro de Pesquisa e Desenvolvimento de Solos e Recursos Ambientais, Instituto Agronômico (IAC), Campinas (SP).

(5) Retired scientific researcher, Instituto Agronômico (IAC).

(6) Centro de Citricultura Sylvio Moreira, Instituto Agronômico (IAC), Caixa Postal 4, 13490-970 Cordeirópolis (SP).

(7) CNPq fellowship.

assessed as rootstock and the 90 most promissing determined among the 394 CTV tolerant hybrids. These hybrids were bud grafted on Rangpur lime and introduced in the Germplasm Collection of Sylvio Moreira Citrus Center . The new accessions included 12 TxS, 29 SxT, 23 SxC, 13 SxA, 7 CxA, 5 TxA and 1 CxS. For better characterization and use as minimum descriptors it is indicated, for each selected hybrid, the genotypes of seven isoenzymatic loci, two loci that govern CTV tolerance and the leaf phenotype in addition to their yield potentials, production efficiency, theoretical tonnage, trunk gummosis and *Phytophthora* root rot tolerances.

Key words: *Poncirus*, isozymes, agroindustrial traits, yield, breeding, Citrus CTV, *Phytophthora*.

RESUMO

HÍBRIDOS DE PORTA-ENXERTOS DE CITROS SELECIONADOS E INTRODUZIDOS NO BAG DO INSTITUTO AGRONÔMICO, CAMPINAS (SP)

Desde 1990, desenvolve-se no Instituto Agronômico (IAC) em Campinas (SP) um programa de melhoramento genético visando desenvolver, via hibridação e seleção, porta-enxertos que associem características favoráveis dos clones comerciais Trifoliata ‘Davis A’ (*Poncirus trifoliata*) (T), tangerina Sunki ‘200’ (*Citrus sunki*) (S), limão Cravo ‘Limeira’ (*Citrus limonia*) (C) e laranja Azeda ‘São Paulo’ (*Citrus aurantium*) (A). Neste trabalho investigaram-se esses genitores representados por 138 clones nucelares e 534 híbridos entre eles identificados por sete locos isoenzímicos e dois marcadores morfológicos, compreendendo sete grupos de cruzamentos (TxS, SxT, SxC, SxA, CxA, TxA e CxS). Genitores e híbridos enxertados com laranja Valência foram estudados quanto às sete primeiras produções, características vegetativas das plantas aos oito anos de idade e suas implicações na produtividade por área, na eficiência da produção por volume da copa, na produção teórica/hectare, realizando-se também testes preliminares da qualidade industrial induzida na copa e observações sobre características dos frutos e sementes de alguns híbridos. Para fins de seleção, consideraram-se, também tolerância à tristeza, gomose e *Phytophthora* de raízes. Com base na existência de variabilidade genética observada visualmente e detectada por parâmetros genéticos, e tomando-se como referência o intervalo de confiança da média dos genitores T, S e C com t a 95% de probabilidade, avaliou-se o potencial dos diferentes genótipos como porta-enxertos, determinando-se, entre 394 tolerantes à tristeza, os 90 híbridos mais promissores. Esses novos acessos compreendem 12 híbridos TxS, 29 SxT, 23 SxC, 13 SxA, 7 CxA, 5 TxA e 1 CxS. Tais híbridos foram enxertados em limão Cravo e incorporados ao Banco Ativo de Germoplasma do Centro de Citricultura Sylvio Moreira. Visando à melhor caracterização e utilização como descritores mínimos, são indicados, para cada híbrido selecionado, os genótipos de sete locos isoenzímicos, de dois locos que governam a tolerância à tristeza e o fenótipo das folhas, além de seus potenciais de produção, produtividade, eficiência, produção teórica, tolerância à gomose e à *Phytophthora* de raízes.

Palavras-chave: *Poncirus*, isoenzimas, características agroindustriais, produtividade, melhoramento, tristeza dos citros.

1. INTRODUCTION

At the start of citrus cropping only plants derived from seeds were used. This was attractive because it was easy, produced long-lived plants and excluded virus, of which there are more than 27 (Castle et al., 1989). However, the advantages of standardization, start of early bearing yield and dissemination of *Phytophthora* in the world made bud grafting on rootstock derived from seeds the universal method of propagating commercial citrus plants. Biologically, the rootstock and scion are symbiotic entities artificially formed by two botanical species that, often from different genus, have to interact harmoniously and efficiently through the grafting region. In spite of the coexistence of such extraordinary genetic divergence the citrus orchard thus formed is genetically uniform, because the canopies are, via bud grafting, vegetative propagations of a single clone and the rootstocks are apogamic reproductions of the mother tree by seed nucellar embryony (Strasburger, 1878; Webber, 1900; Osawa, 1912; Medina Filho et al., 1993).

The result of complex stionic interactions, a term coined by Webber (1932), rootstocks affect dozens of industrial, agronomic and plant health traits related to the fruits and plants of the canopy cultivars grafted on them (Mills, 1902; Bonns & Mertz, 1916; Webber, 1932; Phillips, 1969; Wutscher & Shull, 1975; Castle, 1978, 1987; Russo & Recupero, 1984; Salibe & Mischan, 1984; Teófilo Sobrinho et al., 1984; Castle et al., 1989; Roose et al., 1989; Pompeu Junior, 1990; Ferguson et al., 1990; Richardson et al., 1994; Stuchi et al., 1996). One of the most expressive considerations regarding the importance of rootstock in citrus cropping was made by Wutscher (1979), emphasized by Ferguson et al. (1990), and because of its precision and modernity is quoted here "… rootstocks have contributed perhaps more than any other factor to the success or failure of the citrus industries in the world". Indeed, the history of rootstocks is mixed with the feasibility of the crop and industry implantation in several parts of the world where, in the dynamics of progress, substitution of the Caipira and Sour oranges and the Rangpur lime and Volkamer lemon became classic because of trunk gummosis and CTV incidence, decline and sudden death (Webber, 1948; Wutscher, 1979, 1990; Hutchinson, 1985; Anderson, 1990; Muller, 1990; Ortiz, 1990; Pompeu Júnior, 1990; Roose, 1990; Muller et al., 2002; Machado et al., 2003; Jesus júnior & Bassanezi, 2004; Carlos, 2005).

In the face of the biological vulnerability of the São Paulo state citrus cropping based on few rootstock types, a genetic breeding program has been carried out since 1990 at the Instituto Agronômico de Campinas (Bordignon et al., 1990) to obtain, via hybridization and selection, rootstocks that associate favorable traits of the commercial clones Trifoliate orange, Sunki mandarin, Rangpur lime and Sour orange and thus make scientific research and the citrus agroindustry less dependent on rootstocks selected for conditions in other countries. During this program, the technique of controlled hybridizations has been improved (Bordignon et al., 1990), electrophoresis isoenzymatic marker methodologies have been developed (Ballve et al., 1991, 1995), petiole wing marker (Ballve et al., 1997) used with the trifoliolate leaf marker (Toxopeus, 1962) to identify in seven crossing groups, hundreds of hybrids produced (Medina Filho et al., 2003_a). Bud grafted with Valencia orange, these hybrids were studied in an observation and selection field. In this field, because of the importance (Muller et al., 1990) and implications in citrus rootstock breeding in Brazil (Bordignon et al., 2003_a), the genetic mechanism conditioning tolerance to citrus tristeza virus (CTV) was investigated (Bordignon et al., 2004), as well as the effect of CTV on canopy agronomic and industrial traits (Bordignon et al., 2003_b), resistance to trunk gummosis (Medina Filho et al., 2003_b), root tolerance to *Phytophthora nicotianae* (Medina Filho et al., 2004), the vegetative and industrial traits of the Valencia orange grafted on CTV tolerant hybrids and their three first yields (Bordignon et al., 2003_c). In this last investigation, it was concluded that the production of these hybrids should be followed for a further three or four harvests because of the promising results obtained to date.

In the present work, the first studies on the hybrids were completed by analyzing not only the seven groups of hybrids (TxS, SxT, SxC, SxA, CxA, TxA and CxS) but also the individuals of each group for yield in seven harvests, vegetative traits of the adult plants, the implications for theoretical spacing and yield indexes and for induced industrial quality in the canopy. The fruits, seeds and descent of some hybrids were also observed. Their selection potential was assessed based on these results and also on CTV, trunk gummosis and *Phytophthora* tolerance. The most promising hybrids were determined among the CTV tolerant that were incorporated into the Germplasm Collection for future investigations. Because Brazil is a signed member of the 1978 UPOV Convention (Upov, 1999), and law 9.456/97 for plant protection is in force, it is also indicated for each selected hybrid its genotypes for seven isoenzymatic loci, for two loci that govern CTV tolerance and the leaf phenotype for characterization and use as minimum descriptors.

It is consensus that in any genetic rootstock breeding process the recommendation of a new clone must necessarily be preceded by nursery tests and rigorous competition trials in various locations, for several years and preferably with diverse canopies. This experimentation is expensive, time taking and only justified with a limited number of different genetic materials that have been studied previously and have shown in some way performance or traits of agronomic interest. In this exact context the present study reports the assessment of 534 different hybrids and the selection of the 90 most promising.

2. MATERIAL AND METHODS

This investigation by the Instituto Agronômico de Campinas was carried out in the laboratories and greenhouses of the Genetics Center in Campinas and in the experimental areas in the Sylvio Moreira Citrus APTA Center in Cordeirópolis (22°32' latitude S, 47°27' longitude W, *Cwa* climate, dystrophic red latosoil, precipitation 1323-1734mm). The observation and selection field studied was set up in 1996 in 8x4 m spacing, occupying an area of 2.2 hectares and conducted without irrigation. It is formed by the Valencia BM orange bud grafted on four parent rootstocks, used as controls, Trifoliate orange (T), Sunki mandarin (S), Rangpur lime (C) and Sour orange (A) in a total of 138 plants and also on their respective 534 hybrids, referent to seven groups (treatments) of crosses TxS, SxT, SxC, SxA, CxA, TxA and CxS. The experimental arrangement of the field and the spatial response of the treatments and controls is presented and discussed in detail in Bordignon et al. (2003_c). Briefly, this observation and selection field is formed by 14 adjacent lines with hybrids and parents intercalated forming 48 rows of symmetrical orthogonal disposition presenting a homogeneous spatial response according to the locally-weighted scatterplot smoother (LOWESS) for the rows yield and several other parameters using f=0.5 (fraction of the total number of points) and p=2 (number of robust steps) according to Cleveland (1979). Field homogeneity was indicated also by the non-significant chi square of the Mood test (0.998>p> 0.064) for medians of the yield values and other parameters of the 48 rows (47 G. L.).

Table 1 shows the identification of the parent clones and hybrids, their main attributes and deficiencies, the number of plants studied, abbreviations used, location in the Germplasm Collection and other information.

Controlled pollinations and obtaining of the hybrids studied are reported by Bordignon (1995), the identification of hybrids and nucellar clones by morphological markers by Bordignon (2000), and isoenzymatic markers by Ballve et al., (1991, 1995) with modified GOT-2 reported by Medina Filho et al. (2003_a). The criteria and methods for CTV tolerance assessment are reported in Bordignon et al. (2004), for trunk gummosis in hybrids by Medina filho et al. (2003_b) and for *Phytophthora* in nucellar progenies caused by *Phytophthora nicotianae* by Medina Filho et al. (2004). Details of plant vigor index, determination of fruit total soluble solids (TSS) and the ratio TSS/T (total acidity) are reported in Bordignon (1995). Except for the isoenzymatic genotype determinations, CTV tolerance and the fruit and seeds traits of the hybrids themselves, the Sour orange (A) parent and the CTV intolerant hybrids were not considered in the present study.

The following traits were assessed in 2003, except in the cases indicated. **Plant height** - determined in cm with a graded ruler visualized at approximately 8 m distance. **Canopy diameter** - refers to the mean, in cm, of the diameter in two orthogonal positions of the canopy. **Canopy shape** - index calculated by dividing the canopy height by the diameter. The closer it is to the unit, the more spherical it is. The greater the unit is, the more prolate the shape is, but lower values indicate more oblate shaped plants. **Canopy projection area** - obtained in m^2 by the formula π r^2 where r = canopy diameter /2. **Canopy volume** - the shape of the canopies was considered as half a prolate sphere and volume was obtained in m^3 by the formula 2/3 p r^2 h, where h is the canopy height (Roose et al., 1989; Quaggio et al., 2004). **Stock and scion trunk diameters** - obtained by dividing the perimeters by p, measured in cm, with a tape measure, 5 cm below and above the grafting point. **Congeniality** - quantified by the scion diameter/rootstock diameter ratio (Webber, 1948; Phillips, 1969). **Vigor** - index calculated according to the formula [height + canopy diameter + 10 (rootstock trunk diameter)] / 100 Bordignon et al., 2003_c). **Mean fruit weight** - estimated in grams by the mean of samples of 10 fruits per plant from the 1998 to 2003 harvests. **Accumulated yield** - the sum of the yields from 1997 to 2003 in kg per plant. **Productivity** - obtained in kg/m^2, by the accumulated yield/canopy projection area ratio. **Production efficiency** - in kg/m^3, indicates the accumulated production/canopy volume ratio. **Theoretical tonnage** - in ton/ha was calculated by multiplying the accumulated yield in tons by the theoretical number of plants per hectare at eight years of age.

The latter was obtained from the formula by De Negri and Blasco (1991) of the adequate theoretical spacing E = 0.85D (D+2.5) where D=canopy diameter in meters. **Industrial quality** - a preliminary investigation of the industrial quality of nine promising hybrids and one nucellar clone of the Rangpur lime as a reference was carried out on 10 fruits/plant in October 1999 and 2002 for mean weight (g), mean fruit height and width (cm), juice yield (%), total acidity (%), total soluble solids (Brix) corrected by the juice tritable acidity and TSS/TA ratio, soluble solids/box (kg/box), number of fruits/box and vitamin C content (mg/100 ml) (Di Giorgi et al., 1990; Stuchi et al., 2002; Domingues et al., 2003). **Resistance to trunk gummosis** - assessed in the field in 1999 by the mean area of the lesion caused by *Phytophthora* inoculated in two positions on each hybrid and on all the parents (Medina Filho et al., 2003b). In an additional test for gummosis, the selected TS2195 hybrid was compared to the Trifoliate orange (T), Sunki mandarin (S), and Rangpur lime (C) parents by Siviero (unpublished data) assessing the mean length of the lesion in 10 nucellar seedlings inoculated by the needle method (Siviero, 2001). **Tolerance to *Phytophthora* root rot** - evaluated in 1999 by the total growth reduction index (IR%) (Medina Filho et al., 2003_b) in nucellar progenies of 25 hybrids and in all the parents. **Fruit and seed traits of the parents and some hybrids** - before grafting with Valencia orange, buds were removed from some nucellars and from the hybrids and grafted onto Rangpur lime in a hybrid cloning field referred to as CCHI by Bordignon (2000). General observations were made in 1997, 1998 and/or 1999, of the plants bearing fruits, as to their external and internal aspect. Thirty-eight hybrids from five crossing groups totaling 400 fruits and 499 fruits from the nucellar parents were observed as to the coloring of skin, pulp and seeds, aroma, number of locules and seeds per fruit. **Uniformity of the descent** - the uniformity of descent was investigated in a sample of 30 to 200 seedlings derived from the progeny of 25 different hybrids, that was indicative of the nucellar rate.

Using the above traits, genotypic variability and selection potential of the hybrids were studied. **Genotypic variability** - this was quantified by determining the coefficients of mean genetic variation (cv_G%) of the hybrids according to Vencovsky (1978) as follows: $cv_G\% = s_h / X . 100$, where cv_G% = genotypic variation coefficient, s_h = hybrid standard deviation, and X = general mean. The variation due to environmental effects was estimated by the mean variance of the parents (nucellar clones) by the following expression: $cv_E\% = s_E / X . 100$, where cv_E% = environmental variation coefficient, s_E = environmental standard deviation and X = general mean. The magnitude of the genetic variation compared to the environmental variation was quantified by the b coefficient ($cv_G\% / cv_E\%$) based on Vencovsky (1978). **Selection potential of the hybrids** - this was studied by several criteria. CTV intolerance was eliminatory, determined by various symptoms in several years (Bordignon et al., 2004). The other criteria, using as reference the confidence interval of the mean of the parents with t at 95% probability, were: accumulated yield of the first seven harvests, productivity, production efficiency, theoretical tonnage, canopy height and diameter, trunk gummosis resistance and *Phytophthora* tolerance.

Table 1. Identification in the Germplasm Collection of the rootstock parent clones, their main attributes, deficiencies and their respective hybrids bud grafted with Valencia orange plants at the Centro APTA Citros Sylvio Moreira studied for selection purposes. Total 672 plants.

Species	Genitor	Collection identification	Abbreviation	Nº of Plants	Attributes	Deficiencies
Poncirus trifoliata	Trifoliate orange 'Davis A'	n.º 848 Quadra 30 RG 050 Linha 4	T	33	High resistance to cachexia, gummosis and root rot, tolerance to CTV, sudden death, induces dwarfism and excellent industrial quality to the fruits with good retention on the tree. Early bearing, many polyembryonic seeds.	Intolerance to decline and Capão Bonito CTV strain, susceptibility to exocortis and drought, incompatible with "Pêra" sweet orange canopy
Citrus sunki	Sunki mandarin '200'	n.º 200 Coleção clones velhos Banco de Matrizes RG 050 Linha 13	S	48	Robustness, tolerant to cachexia, CTV including the Capão Bonito strain, decline and sudden death. Induces reasonable fruit quality.	Late bearer, susceptible to exocortis, gummosis and root rot, moderate robustness, less drought tolerant than Rangpur lime, few seeds per fruit, reduced polyembryony, high % of zygotic embryos.
Citrus limonia	Rangpur lime 'Limeira'	n.º 863 Quadra 30 Banco de Matrizes RG 050 Linha 14	C	48	Robustness, longevity, CTV tolerant, reasonable gummosis resistance, early bearer, excellent drought resistance, high yield, many seeds, vigorous seedlings	Susceptible to cachexia and exocortis, intolerant to the Capão Bonito CTV strain, sudden death and decline
Citrus aurantium	Sour orange 'São Paulo'	n.º 244 Coleção clones velhos n.º285 Quadra 16 RG 050 Linha 12	A	9	Robustness, longevity, good tolerance to exocortis, cachexia and gummosis, induces high tolerance to cold and excellent fruit quality, good retention on the tree, wide adaptability and compatibility, deep multiple tap roots.	CTV intolerant.
			Total	**138**		

Hybrids					General observation on the hybrid group
P. trifoliata x *C. sunki*	Trifoliate x Sunki	RG 050 Linha 2	T x S	20	Segregates for CTV tolerance, *Phytophthora* root rot tolerance equal or superior to Rangpur lime, rootstock overgrowth at bud union.
C. sunki x *P. trifoliata*	Sunki x Trifoliate	RG 050 Linha 2 to 4	S x T	67	Idem TxS.
C. sunki x *C. limonia*	Sunki x Rangpur lime	RG 050 Linha 5 to 9	S x C	207	CTV tolerant, great vegetative vigor, low yield, low *Phytophthora* root rot tolerance.
C. sunki x *C. aurantium*	Sunki x Sour orange	RG 050 Linha 9 to 11	S x A	98	Segregates for CTV and *Phytophthora* root rot tolerance, great vegetative vigor.
C. limonia x *C.aurantium*	Rangpur lime x Sour orange	RG 050 Linha 11 and 12	C x A	48	Segregates for CTV tolerance.
P. trifoliata x *C. aurantium*	Trifoliate x Sour orange	RG 050 Linha 1 and 2	T x A	65	Segregates for CTV, gummosis and *Phytophthora* root rot tolerance, reduced vegetative vigor, rootstock overgrowth at bud union with Valencia orange.
C. limonia x *C. sunki*	Rangpur lime x Sunki	RG 050 Linha 4 and 5	C x S	29	Idem SxC.
			Total	**534**	

Obs: CTV = citrus tristeza virus

The MINITAB version 14 software was used for analysis of variance, and the tests, mean calculation, standard deviations, confidence interval of the mean with t at 95% probability, maximum, minimum and separating values (first, median and third quartile) and Pearson correlations (product-moment).

3. RESULTS AND DISCUSSION

Synthesis of previous data - For greater clarity in the research reported here and in the ensuing discussion, a synthesis of the previous data on the genetic diversity and general performance of parents and each hybrid group is presented in Table 2. The behavior of the parents Trifoliate orange (T), Sunki mandarin (S), Rangpur lime (C) and Sour orange (A) as to CTV, *Phytophthora,* vigor, Brix and the TSS/TA ratio, already known because of wide use in Brazilian citrus cropping (Pompeu Junior et al., 1975; Salibe and Moreira, 1984; Pompeu Junior, 1990; 1991; Stuchi et al., 1996; Teófilo Sobrinho et al., 1999), was confirmed by these previous studies carried out in the observation and selection field that thus validated the comparisons and considerations regarding the hybrids, justifying the continuing assessment of these materials and their reports in the present study. It is pointed out that the data presented refer, except in cases mentioned in material and methods, only to the CTV tolerant parents and hybrids, because of the influence of this disease on the investigated traits (Bordignon et al., 2003_b). The data of the TxA hybrids, for example, refer to the Az az TT genotype, that is tolerant to this disease and in the TxS group, to those of the Az Az Tt and Az az Tt genotypes.

Analysis of the parents and hybrids traits - data of the various traits studied in the Valencia orange grafted on the parents and their hybrids showed the ANOVA F tests to be significant ($p<0.05$). Table 3 shows descriptive statistics and confidence intervals with t at 95% probability. Figure 1 shows the uniformity of the Valencia orange canopy on the nucellar clones of parents and the variability induced by the different hybrids for vegetative and productive traits.

Canopy height, diameter and projection area - Valencia orange plants on Sunki mandarin reached greater mean heights (337 cm) than on Rangpur lime (292 cm) or on Trifoliate orange (227 cm), at the 95% confidence level (Table 3). Valencia orange performed similarly on the Sunki mandarin with Rangpur lime and Sour orange hybrids. Reciprocal Sunki mandarin and Trifoliate orange hybrids and those between Rangpur lime and Sunki mandarin induced intermediate heights presenting values closer to Trifoliate orange. The data for the canopy diameters and consequently the canopy projection area were similar to the height, and again Sunki mandarin and its hybrids with Rangpur lime and Sour orange induced the greatest canopy diameters and canopy projection areas, notable for the intermediate values of the mean of the TxS, SxT, and CxS hybrids. The marked influence of Sunki mandarin and Sour orange for inducing taller plants, with greater diameters and larger canopy projection areas was detected in some of their hybrids by the maximum values (Max) and by the third quartiles of these parameters in the SxC, SxA, CxA and CxS. On the other hand, the influence of Trifoliate orange in decreasing height and canopy diameter was observed in the TxS, SxT, and TxA hybrids by the minimum values (Min) and the first quartile. Segregation for these traits in these groups is shown by the Q_1 and Q_3 values. **Canopy shape** - The plants grafted on Sunki mandarin, Rangpur lime and their hybrids, including Sour orange, presented the greatest heights and diameters and values closest to 1.00 in the height/diameter ratios, thus showing that these canopies are large and spherical. Trifoliate orange tended to induce smaller canopies and height/diameter close to 0.90. The TxS, SxT and TxA hybrids showed the lowest canopy shape indexes, respectively, 0.84, 0.87 and 0.86, although the first two induced greater height and diameter than the Trifoliate orange parent. Therefore the expression of the dwarfing trait of the Trifoliate parent in the TxS and SxT hybrids was proportionately more intense in reducing the height than the width resulting in more oblate shaped canopies. The TxA hybrids tended to induce medium heights and diameters that did not differ from the Trifoliate orange, as shown by the mean and the confidence interval. The 0.86 value of the canopy shape was also explained by a mean reduction (5.5%), proportionately greater in the height than in the width (2.7%) in the plants**. Canopy volume** - the canopy volumes of Valencia orange grafted on the Trifoliate orange, Sunki mandarin and Rangpur lime parents corroborated the investigations by Teófilo Sobrinho (1972) who observed smaller volumes in Trifoliate orange, greater volumes in Sunki mandarin and intermediate volumes in Rangpur lime. The SxC and SxA hybrids induced voluminous canopy with means equal to those in Sunki mandarin with 95% confidence. However, a slight tendency to even greater values than this parent was observed when the medians and the Q_3 were analyzed together. The TxA hybrids induced small canopies tending even to values lower than Trifoliate orange as shown by the median and Q_1. The TxS, SxT, CxA and CxS hybrids generally induced canopies with volumes intermediate between Trifoliate orange and Sunki mandarin. The CxA hybrids presented considerable variability for this trait as shown by the CV%. **Stock and scion trunk diameters** - a very distinct group was observed in the CI analysis for of these traits formed by Trifoliate orange and the SxT, CxA and TxA hybrids with reduced values, especially for the TxA hybrids. Sunki mandarin and its hybrids with Rangpur lime presented higher values, and were intermediate to those of Rangpur lime and the TxS and SxA hybrids. The variability existing in the TxS hybrids is remarkable as can be verified by the CI dispersion, CV%, Q_1 and Q_3 values (Table 3). The stock and scion trunk diameters were reduced in the canopies grafted on Trifoliate orange and on its hybrids with Sour orange. The greatest values were observed in Valencia orange grafted on Sunki mandarin, Rangpur lime and on the SxC, SxA and CxS hybrids and intermediate values were observed for the TxS, SxT and CxA hybrids. **Vigor** - Trifoliate orange, by reducing the stock and scion trunk diameters, height and diameter of canopy that together compose vigor resulted in the low values for this parameter in the plants grafted on it and on the TxA hybrids. The greatest vigor values were observed in Sunki mandarin and in its hybrids with Rangpur lime and Sour orange. The canopy, stock and scion trunks diameters generally corresponded with plant height. Indeed, Pearson correlations (product-moment) for these four parameters ranged from 81 to 91% ($p<0.01$). **Congeniality** – when the rootstock was S, C, SxC, CxS, SxA or CxA hybrids, the Valencia orange canopy showed, in the graft region, a smooth transition to the stock indicated by high values of their diameter ratio that ranged, on average, from 0.88 to 0.92. Conversely grafts on Trifoliate orange and all its hybrids presented lower congeniality indicated by values ranging from 0.71 to 0.77, and development of conspicuous rootstock overgrowth at bud union (Figure 2). This Trifoliate orange trait is therefore dominant. Moreover, according to the mean, median, amplitude variation and confidence intervals, it manifested more intensely in the combinations where this species was the female parent, a suggestive indication of cytoplasmic influence. Because it is particular to Trifoliate orange and manifested in its TxS, SxT and TxA hybrids with somewhat variable intensity, the possibility of correlation with other plant or yield traits was investigated. None of the nine traits tested showed correlation (Pearson product-moment) significant at 5%. **Mean fruit weight** - small differences in mean variations ranging from 192 to 212g were observed. However, the TxS, SxA and TxA hybrids tended to induce larger fruits as can be observed by the amplitudes of the confidence intervals and also by the values of the third quartile showing that 25% of their fruit weighted over 211 g. Higher first quartile and median values corroborated this tendency. Large fruits have little industrial value, but are attractive for fresh markets. Visual observations indicated, in addition to size, obvious differences in internal coloring and in the thickness of the pericarp of fruits induced by some hybrids (Figure 3).

Yield, productivity, production efficiency and theoretical tonnage - The results of the yields accumulated in seven harvests (Table 3) showed that the plants grafted on Trifoliate orange were, on average, less productive (154 kg) than those grafted on Rangpur lime (212 kg) at the 95% confidence level. The accumulated yields of the TxS (267 kg) and SxT (215 kg) hybrids did not differ and both were greater than the yields of the other hybrids at 95% confidence interval. The SxT hybrids induced yields equivalent to Rangpur lime in this period. The production of the plants on Sunki mandarin was intermediate between that of Trifoliate orange and Rangpur lime or SxT hybrids, although the values did not differ statistically. The other hybrids (SxC, SxA, CxA, TxA and CxS) induced lower yields on average although they did not differ statistically from the values of Trifoliate orange and Sunki mandarin. Close spacing is a current tendency in citrus cropping. It gives faster returns on investment due to greater yield per area in the first years (Phillips, 1969; Teófilo Sobrinho et al., 2002), reduces operational risks, harvesting and spraying. Ideal density depends on plant size and yield, thus the interest in its interrelationships. When yield was considered compared to the canopy projection area (productivity), compared to volume (production efficiency) or even calculated on theoretical basis considering spacing suitable for the canopy diameter at eight years of age, it was observed that Valencia orange on Sunki mandarin and its hybrids (SxC, SxA and CxS), except those with Trifoliate orange (TxS and SxT) presented lower values, while Trifoliate orange and Rangpur lime and the TxS and SxT hybrids showed the best performances that indicated the preponderance of this Trifoliate orange trait in its hybrids. Similarly to the plants grafted on Sunki mandarin, plants in the SxC, SxA and CxS hybrids were vigorous, but the yields did not increase proportionally to vigor resulting in low productivity and production efficiency.

The greater productivity of the plants on the TxS and SxT hybrids was due to a favorable combination of yield and vigor. When yield per plant was considered, low values were observed for the plants on Trifoliate orange and high values for those in the TxS hybrids. Plants on Sunki mandarin, Rangpur lime and the SxT hybrids showed intermediate values. However, when yield was considered by the canopy projection area (productivity), a tendency was observed of reduced differences in the values of the plants among Trifoliate orange, Rangpur lime and the TxS and SxT hybrids. There was an accentuated fall in the values of the plants on Sunki mandarin because it induced great vegetative vigor. The same occurred when yield/m^3 (efficiency) was considered where the data of the plants on Trifoliate orange were superior to those on Rangpur lime coming even closer to those in the TxS and SxT hybrids. Trifoliate orange is known (Phillips, 1969; Teófilo Sobrinho, 1972; Roose et al., 1989) for inducing high production efficiency and it is interesting to note that this trait was manifested with great intensity in its hybrids with Sunki mandarin and Sour orange. The TxA hybrids presented reasonable productivity and efficiency because they induced reduced height, canopy diameter and yield. The theoretical tonnage followed the same proportions regarding productivity, because of its dependence on the plant canopy diameter. The above considerations are shown in the confidence interval graphs (Table 3) and in Figure 1. The fact that the TxS, SxT and TxA hybrids presented high Q_3 values for these traits is especially interesting for breeding.

Table 2. Synthesis of previous data on the studied clones and their respective hybrid groups.

Genitors and	Isoenzyme genotypes							Tristeza tolerance		Phytophthora		2000	1999	
hybrids	*Pgi-1*	*Pgm-1*	*Got-1*	*Got-2*	*Prxa-1*	*Me-1*	*Aps-1*	Genotype	Reaction	Gummosis cm²	Root rot IR%	Vigor index	°Brix	Ratio
Trifoliate (T)	FS	PM	PM	SS.MT	FF	RR	NN	Az az tt	Tol	2,0	3	6,5	10,8	15,1
Sunki (S)	FF	FF	SS	FF.MM	FM	II	CC	Az az tt	Tol	5,5	71	8,4	9,9	11,9
Rangpur lime (C)	FS	FF	FS	FS.MM	MM	II	CC	Az az tt	Tol	4,6	36	8,1	9,3	11,5
Sour orange (A)	WS	FS	SS	FM.MM	FS	II	CC	az az TT	Intol	2,6	32	-	-	-
TxS	FS	FP	PS	FS.MT	FF	RI	CN	Az Az Tt	Tol	2,4	26	7,8	9,6	13,3
	FF	MF	MS	FS.MM	FM			Az az Tt	Tol					
								az az Tt	Intol					
SxT	FS	FP	PS	FS.MT	FF	RI	CN	Az Az Tt	Tol	2,5	27	7,2	10,4	13,1
	FF	MF	MS	FS.MM	FM			Az az Tt	Tol					
								az az Tt	Intol					
SxC	FF	FF	FS	FF.MM	FM	II	CC	Az Az tt	Tol	4,7	85	8,6	9,3	13,0
	FS		SS	FS.MM	MM			Az az tt	Tol					
								az az tt	Tol					
SxA	WF	FS	SS	FF.MM	FF	II	CC	Az az Tt	Tol	4,1	43	8,1	9,4	12,8
	FS	FF		FM.MM	FS			az az Tt	Intol					
					FM									
					MS									
CxA	WF	FS	FS	FF.MM	FM	II	CC	Az az Tt	Tol	4,1	-	7,2	9,8	12,6
	WS	FF	SS	FS.MM	MS			az az Tt	Intol					
	FS			FM.MM										
	SS			MS.MM										
TxA	FW	FP	PS	FS.MM	FF	RI	CN	Az az TT	Tol	3,0	40	6,5	10,2	13,0
	FS	PS	MS	FS.MT	FS			az az TT	Intol					
	WS	FM		MS.MM										
	SS	MS		MS.MT										
CxS	FF	FF	FS	FF.MM	FM	II	CC	Az Az tt	Tol	5,8	-	8,1	9,6	12,5
	FS		SS	FS.MM	MM			Az az tt	Tol					
								az az tt	Tol					

Obs: Alternative genotypes derived from heterozygote locus segregation in the parents is indicated; GOT-2 is a duplicate locus; in APS-1, N refers to the Null allele derived from Trifoliata Davis A; CTV tolerance (Tol) is controlled by two independent loci interacting in dominant-recessive epistasis; *Phytophthora* values refer to the mean area of the gummosis lesion in two inoculations/adult plant and therefore the area of lesion is proportional to the susceptibility; the root rot values refer to the total plant reduction mean (IR%) due to root infection in clonal progenies and thus, proportional to susceptibility; vigor index refers to mean values in 2000; °Brix and TSS/TA ratio refer to mean values in the 1999 harvest.

Table 3. Descriptive statistics of several characteristics studied in Valencia orange grafted on the Trifoliate orange (T), Sunki mandarin (S), Rangpur lime (C) parents and their CTV tolerant hybrids (A= intolerant Sour orange parent). It is shown the number of plants (n), mean (m), sample standard deviation (s), standard error of the mean (s(m)), confidence interval (CI) of the mean with t at 95% probability, sample variance (V), minimum (Min) and maximum (Max) values, first (Q_1) and third quartiles (Q_3), coefficients of environmental variation (cv_E%) in the T, S, C parents and of genotypic variation (cv_G%) in the hybrids (CV%), b coefficient (cv_G% / cv_E%) and Confidence Interval graphs, indicating the mean and its limits.

Clone/hybrid	n	m	s	s(m)	CI	V	Min	Q_1	Median	Q_3	Max	CV%	b	Confidence Interval with t at 95% probability
								Plant height (cm)						
T	32	227,5	29,1	5,1	217,0-238,0	845,2	130,0	212,5	240,0	240,0	260,0	12,8	-	(--*-)
S	48	336,9	35,9	5,2	326,5-347,3	1285,8	270,0	302,5	340,0	367,5	400,0	10,6	-	(-*--)
C	47	292,1	25,0	3,7	284,8-299,5	625,8	230,0	270,0	290,0	310,0	340,0	8,5	-	(-*--)
TxS	16	265,0	58,2	14,5	234,0-269,0	3386,7	190,0	202,5	285,0	317,5	350,0	18,8	1,77	(---*---)
SxT	45	252,7	53,3	7,9	236,6-268,7	2842,7	150,0	215,0	260,0	290,0	360,0	17,9	1,64	(--*-)
SxC	200	339,1	44,9	3,2	332,8-345,4	2017,3	210,0	310,0	345,0	380,0	400,0	10,0	0,94	(*)
SxA	60	329,5	38,3	4,9	319,6-339,4	1469,2	240,0	300,0	330,0	360,0	400,0	7,1	0,67	(-*-)
CxA	27	253,3	53,0	10,2	232,4-274,3	2805,8	160,0	220,0	240,0	285,0	390,0	17,2	1,62	(---*--)
TxA	20	215,0	35,2	7,9	198,5-231,4	1236,8	160,0	190,0	215,0	240,0	290,0	8,3	0,78	(---*---)
CxS	26	315,8	37,4	7,3	300,6-330,9	1401,4	240,0	290,0	310,0	340,0	390,0	7,0	0,66	(--*--)
														-+---------+---------+---------+-----
														200 250 300 350
								Canopy diameter (cm)						
T	32	258,4	43,6	7,7	242,7-274,1	1897,5	90,0	242,5	275,0	290,0	310,0	16,9	-	(----*---)
S	48	335,4	39,0	5,6	324,1-346,7	1520,0	240,0	312,5	330,0	350,0	420,0	11,6	-	(---*---)
C	47	296,3	25,8	3,8	288,7-303,8	664,6	240,0	280,0	295,0	310,0	360,0	8,7	-	(---*--)
TxS	16	313,8	62,9	15,7	280,2-347,3	3958,3	230,0	252,5	300,0	380,0	400,0	16,2	1,31	(------*-----)
SxT	45	290,3	57,0	8,5	273,2-307,4	3248,2	180,0	255,0	280,0	330,0	400,0	14,9	1,20	(---*---)
SxC	200	345,3	45,4	3,2	339,0-351,7	2060,9	210,0	310,0	350,0	380,0	420,0	7,7	0,62	(-*)
SxA	60	345,6	45,8	5,9	333,7-357,4	2099,2	250,0	310,0	340,0	387,5	430,0	7,8	0,63	(---*--)
CxA	27	276,1	51,8	10,0	255,6-296,6	2679,5	150,0	245,0	270,0	310,0	410,0	13,1	1,06	(----*----)
TxA	20	251,5	44,0	9,9	230,9-272,1	1939,7	180,0	212,0	255,0	287,5	320,0	9,5	0,77	(-----*-----)
CxS	26	311,9	43,2	8,5	294,5-329,4	1864,1	240,0	290,0	310,0	342,0	390,0	7,2	0,58	(----*----)
														----+---------+---------+---------+--
														245 280 315 350

Continue

Table 3. Continuation

Clone/hybrid	n	m	s	s(m)	CI	V	Min	Q_1	Median	Q_3	Max	CV%	b	Confidence Interval with t at 95% probability
									Canopy shape					
T	32	0,90	0,13	0,02	0,85-0,94	0,0165	0,68	0,83	0,88	0,94	1,44	14,3	-	(---*----)
S	48	1,01	0,11	0,02	0,98-1,04	0,0133	0,79	0,95	1,00	1,06	1,58	11,4	-	(--*---)
C	47	0,99	0,07	0,01	0,97-1,01	0,0446	0,87	0,94	0,98	1,03	1,15	6,7	-	(---*---)
TxS	16	0,84	0,08	0,02	0,80-0,89	0,0068	0,68	0,78	0,85	0,89	1,03	-	-	(------*-----)
SxT	45	0,87	0,08	0,01	0,84-0,89	0,0066	0,71	0,83	0,86	0,92	1,19	-	-	(---*---)
SxC	200	0,98	0,08	0,01	0,97-1,00	0,0691	0,68	0,94	0,98	1,03	1,28	-	-	(-*-)
SxA	60	0,96	0,09	0,01	0,94-0,98	0,0783	0,79	0,90	0,95	1,00	1,41	24,1	2,23	(--*--)
CxA	27	0,92	0,10	0,02	0,88-0,96	0,0100	0,57	0,87	0,93	0,97	1,08	-	-	(----*---)
TxA	20	0,86	0,08	0,02	0,82-0,90	0,0678	0,70	0,80	0,85	0,93	1,05	24,1	2,23	(-----*-----)
CxS	26	1,01	0,09	0,02	0,98-1,05	0,0857	0,83	0,97	1,00	1,05	1,25	24,4	2,26	(----*-----)
														------+---------+---------+---------+
														0,840 0,910 0,980 1,050
									Canopy projection area (m²)					
T	32	5,4	1,5	0,3	4,8-5,9	2,3	0,6	4,6	5,9	6,6	7,5	28,2	-	(---*---)
S	48	9,0	2,1	0,3	8,4-9,6	4,3	4,5	7,6	8,6	9,6	13,9	23,1	-	(--*--)
C	47	6,9	1,2	0,2	6,6-7,3	1,5	4,5	6,2	6,8	7,5	10,2	17,5	-	(---*--)
TxS	16	8,0	3,1	0,8	6,3-9,7	9,8	4,2	5,0	7,0	11,3	12,6	33,0	1,44	(----*-----)
SxT	45	6,9	2,6	0,4	6,1-7,7	7,0	2,5	5,1	6,2	8,6	12,6	29,8	1,30	(--*---)
SxC	200	9,5	2,4	0,2	9,2-9,9	5,8	3,5	7,5	9,6	11,3	13,9	18,3	0,80	(-*)
SxA	60	9,5	2,5	0,3	8,9-10,2	6,2	4,9	7,5	9,1	11,7	14,5	19,5	0,85	(--*--)
CxA	27	6,2	2,3	0,4	5,3-7,1	5,3	1,8	4,7	5,7	7,5	13,2	25,6	1,12	(---*---)
TxA	20	5,1	1,7	0,4	4,3-5,9	3,0	2,5	3,5	5,1	6,5	8,0	10,5	0,46	(----*---)
CxS	26	7,8	2,1	0,4	6,9-8,6	4,4	4,5	6,6	7,5	9,2	11,9	16,5	0,72	(---*---)
														----------+---------+---------+------
														6,0 8,0 10,0

Table 3. Continuation

Clone/hybrid	n	m	s	s(m)	CI	V	Min	Q1	Median	Q3	Max	CV%	b	Confidence Interval with t at 95% probability
									Canopy volume (m³)					
T	32	8,4	2,8	0,5	7,4-9,4	8,0	0,5	7,3	8,7	8,7	10,6	33,3	-	(---*---)
S	48	20,4	6,4	0,9	18,5-22,3	41,1	8,9	16,2	19,6	22,9	36,9	31,4	-	(--*--)
C	47	13,7	3,3	0,5	12,7-14,6	10,8	6,9	11,7	13,2	15,5	22,4	24,1	-	(--*--)
TxS	16	15,2	8,5	2,1	10,7-19,8	72,7	6,0	7,1	13,6	23,4	29,3	44,7	1,51	(----*-----)
SxT	45	12,4	7,0	1,0	10,3-14,5	49,6	2,7	7,2	11,0	15,9	28,7	41,1	1,39	(---*--)
SxC	200	22,1	7,8	0,5	21,0-23,2	60,2	5,8	15,9	21,8	28,0	36,9	26,9	0,91	(-*)
SxA	60	21,4	7,5	1,0	19,5-23,4	56,4	7,9	15,2	20,8	28,3	37,7	26,3	0,89	(--*--)
CxA	27	11,1	6,7	1,3	8,5-13,8	44,5	1,9	7,1	9,1	13,4	34,3	38,8	1,31	(----*---)
TxA	20	7,6	3,6	0,8	6,0-9,3	12,9	2,9	5,1	7,4	10,0	14,6	-	-	(----*----)
CxS	26	16,8	6,3	1,2	14,2-19,4	40,2	7,3	13,7	15,6	20,7	31,1	25,2	0,85	(---*---)
														---+---------+---------+---------+---
														6,0 12,0 18,0 24,0
									Stock trunk diameter (cm)					
T	32	14,6	2,2	0,4	13,8-15,4	5,0	6,4	14,0	15,0	15,8	17,5	15,1	-	(---*---)
S	48	18,5	1,9	0,3	17,9-19,0	3,4	13,4	17,5	18,3	19,9	22,3	10,3	-	(--*---)
C	47	16,7	1,3	0,2	16,3-17,1	1,8	13,7	15,6	16,6	17,8	20,7	7,8	-	(---*--)
TxS	16	17,1	4,1	1,0	14,9-19,3	17,0	12,1	12,9	17,9	19,5	26,1	21,6	1,94	(-----*-----)
SxT	45	14,6	3,3	0,5	13,6-15,6	10,9	8,3	12,1	14,6	16,7	21,3	18,8	1,69	(---*---)
SxC	199	18,2	2,4	0,2	17,9-18,6	5,9	11,5	16,9	18,1	20,1	24,8	8,7	0,78	(*-)
SxA	60	17,1	2,2	0,3	16,6-17,7	5,0	11,1	15,7	17,2	18,7	21,6	7,4	0,67	(--*--)
CxA	27	14,2	3,0	0,6	13,0-15,4	9,1	8,0	12,1	14,0	16,6	22,9	16,8	1,51	(----*----)
TxA	20	13,0	2,8	0,6	11,6-14,3	8,0	7,3	10,6	13,4	14,9	17,8	16,4	1,48	(-----*----)
CxS	26	17,7	1,8	0,4	16,9-18,4	3,4	13,7	16,9	17,9	18,9	20,7	-	-	(---*----)
														-+---------+---------+---------+-----
														12,0 14,0 16,0 18,0

Continue

Table 3. Continuation

Clone/hybrid	n	m	s	s(m)	CI	V	Min	Q1	Median	Q3	Max	CV%	b	Confidence Interval with t at 95% probability
Scion trunk diameter (cm)														
T	32	10,4	2,0	0,3	9,7-11,1	3,9	4,1	9,0	10,5	11,5	15,3	19,2	-	(--*-)
S	48	17,0	1,7	0,2	16,5-17,5	3,1	12,4	15,9	16,9	18,4	20,7	10,0	-	(-*-)
C	47	15,4	1,2	0,2	15,1-15,8	1,6	11,1	14,6	15,6	16,2	17,8	7,8	-	(-*--)
TxS	16	11,9	3,3	0,8	10,2-13,7	10,9	8,3	9,0	11,8	14,6	18,5	24,0	1,95	(---*--)
SxT	45	11,3	2,8	0,4	10,4-12,1	7,9	6,7	9,0	11,1	13,4	17,5	20,5	1,67	(--*-)
SxC	199	16,7	2,2	0,2	16,4-17,0	5,0	10,5	15,6	16,9	18,1	22,9	9,1	0,74	(*)
SxA	60	15,7	2,2	0,3	15,2-16,3	4,7	10,8	14,3	15,6	17,5	20,4	8,9	0,72	(*-)
CxA	27	12,5	2,8	0,5	11,4-13,5	7,4	6,7	10,8	12,1	14,0	20,1	17,6	1,43	(--*-)
TxA	20	9,4	2,0	0,4	8,4-10,3	3,9	5,7	8,4	9,0	10,8	12,4	11,2	0,91	(--*--)
CxS	26	15,6	2,0	0,4	14,8-16,4	4,2	11,8	13,7	15,7	17,0	19,7	7,6	0,62	(--*--)
														---+---------+---------+---------+---
														9,0 12,0 15,0 18,0
Congeniality														
T	32	0,71	0,09	0,02	0,68-0,74	0,0833	0,58	0,64	0,69	0,74	0,94	12,7	-	(--*-)
S	48	0,92	0,03	0,00	0,91-0,93	0,0117	0,80	0,90	0,93	0,94	1,00	3,3	-	(-*-)
C	47	0,92	0,04	0,01	0,91-0,94	0,0185	0,79	0,90	0,93	0,96	1,00	4,3	-	(-*--)
TxS	16	0,70	0,08	0,02	0,66-0,74	0,0575	0,53	0,67	0,69	0,72	0,86	19,7	2,90	(---*---)
SxT	45	0,77	0,07	0,01	0,75-0,79	0,0484	0,49	0,73	0,78	0,81	0,93	13,2	1,94	(--*-)
SxC	199	0,92	0,05	0,00	0,91-0,93	0,0274	0,74	0,88	0,92	0,95	1,07	-	-	(*)
SxA	60	0,92	0,07	0,01	0,90-0,94	0,0439	0,70	0,88	0,92	0,96	1,17	8,3	1,22	(-*-)
CxA	27	0,88	0,07	0,01	0,85-0,91	0,0509	0,67	0,85	0,88	0,94	0,97	12,9	1,90	(--*--)
TxA	20	0,73	0,08	0,02	0,69-0,76	0,0642	0,61	0,66	0,71	0,79	0,92	22,4	3,30	(--*--)
CxS	26	0,88	0,07	0,01	0,85-0,91	0,0483	0,68	0,86	0,89	0,93	0,98	11,6	1,70	(--*-)
														-------+---------+---------+---------
														0,720 0,800 0,880

Continue

Table 3. Continuation

Clone/hybrid	n	m	s	s(m)	CI	V	Min	Q1	Median	Q3	Max	CV%	b	Confidence Interval with t at 95% probability
Vigor														
T	32	6,3	0,9	0,2	6,0-6,6	0,8	2,8	5,9	6,5	6,9	7,3	14,3	-	(--*---)
S	48	8,6	0,8	0,1	8,3-8,8	0,6	6,5	8,1	8,4	9,1	10,4	9,3	-	(--*--)
C	47	7,6	0,6	0,1	7,4-7,7	0,3	6,1	7,2	7,5	7,9	9,0	7,9	-	(--*--)
TxS	16	7,5	1,6	0,4	6,7-8,3	2,4	5,6	5,8	7,7	8,9	10,1	18,8	1,79	(----*----)
SxT	45	6,9	1,4	0,2	6,5-7,3	1,9	4,2	5,9	6,9	7,8	9,6	17,4	1,66	(--*--)
SxC	199	8,7	1,1	0,1	8,5-8,8	1,1	5,9	7,9	8,8	9,5	10,6	8,7	0,83	(-*)
SxA	60	8,5	1,0	0,1	8,2-8,7	1,0	6,0	7,8	8,4	9,4	10,3	8,1	0,77	(--*-)
CxA	27	6,7	1,3	0,2	6,2-7,2	1,6	3,9	5,9	6,5	7,5	10,3	15,8	1,50	(---*---)
TxA	20	5,9	1,0	0,2	5,5-6,4	1,0	4,3	5,3	6,0	6,7	7,6	11,5	1,10	(----*---)
CxS	26	8,0	0,9	0,2	7,7-8,4	0,8	6,4	7,4	8,0	8,6	9,8	6,2	0,59	(---*---)
														------+---------+---------+---------+
														6,0 7,0 8,0 9,0
Mean fruit weight (g)														
T	30	198,3	12,8	2,3	193,5-203,1	164,8	167,0	186,9	201,6	207,5	218,3	6,4	-	(-----*------)
S	45	191,7	15,4	2,3	187,1-196,4	238,7	146,3	181,8	193,3	202,3	216,7	8,0	-	(-----*----)
C	46	200,5	13,4	2,0	196,5-204,5	180,6	148,7	193,2	201,5	207,8	226,7	6,7	-	(-----*----)
TxS	16	211,9	11,0	2,7	206,1-217,8	121,4	192,0	202,8	215,8	220,9	226,0	-	-	(--------*--------)
SxT	44	200,6	16,8	2,5	195,5-205,7	281,5	161,3	190,5	203,5	213,2	232,7	4,5	0,65	(-----*----)
SxC	176	205,4	19,5	1,5	202,5-208,3	381,0	152,0	191,9	207,7	219,2	253,3	6,6	0,94	(-*--)
SxA	51	210,0	19,1	2,7	204,6-215,4	364,4	174,3	197,3	211,0	222,0	249,3	6,1	0,87	(----*----)
CxA	26	194,6	29,7	5,8	182,6-206,6	883,8	141,0	172,9	200,5	212,4	272,0	13,3	1,90	(------*------)
TxA	20	209,8	16,6	3,7	202,0-217,6	276,8	177,0	195,8	206,8	223,1	239,0	4,3	0,61	(-------*-------)
CxS	21	195,3	18,9	4,1	186,6-203,9	359,4	163,7	182,3	193,7	206,5	235,3	6,5	0,93	(-------*-------)
														----+---------+---------+---------+--
														190 200 210 220

Continue

Table 3. Continuation

Clone/hybrid	n	m	s	s(m)	CI	V	Min	Q_1	Median	Q_3	Max	CV%	b	Confidence Interval with t at 95% probability
Accumulated yield (kg/plant)														
T	32	153,9	44,9	7,9	137,7-170,1	2013,2	10,1	138,3	157,9	186,8	212,0	29,2	-	(----*---)
S	48	183,2	57,2	8,3	166,6-199,8	3271,8	50,0	147,0	174,7	220,0	325,4	31,2	-	(---*--)
C	47	212,2	47,3	6,9	198,3-226,1	2238,0	102,3	188,1	209,6	248,7	340,2	22,3	-	(--*---)
TxS	16	267,2	117,2	29,3	204,7-329,7	13743,6	146,6	163,9	219,4	398,9	472,2	40,0	1,45	(-----*------)
SxT	45	215,3	72,7	10,8	193,5-237,2	5286,9	94,5	168,9	205,7	252,8	398,0	24,6	0,89	(---*---)
SxC	200	165,0	60,0	4,2	156,7-173,4	3594,9	50,6	121,9	159,3	200,8	347,2	20,4	0,74	(-*-)
SxA	60	163,2	70,3	9,1	145,0-181,3	4940,7	14,1	118,5	144,7	213,4	381,3	30,3	1,10	(---*--)
CxA	27	156,4	67,2	12,9	129,8-183,0	4517,0	39,6	101,5	163,1	195,8	307,8	29,3	1,06	(----*----)
TxA	20	143,3	79,0	17,7	106,3-180,2	6240,1	48,0	75,6	123,7	195,7	327,0	43,6	1,58	(-----*----)
CxS	26	141,5	50,0	9,8	121,3-161,7	2503,8	57,0	101,0	141,8	168,8	244,9	-	-	(----*----)
														-------+---------+---------+---------
														150 200 250
Productivity (kg/m²)														
T	32	28,6	6,5	1,1	26,3-30,9	42,1	15,9	24,9	28,0	31,6	45,7	22,7	-	(---*---)
S	48	21,6	8,5	1,2	19,1-24,0	71,6	4,0	16,2	20,4	26,1	54,3	39,3	-	(---*--)
C	47	30,8	6,2	0,9	29,0-32,6	38,5	18,5	26,2	30,5	35,2	48,1	20,1	-	(---*---)
TxS	16	34,0	8,0	2,0	29,8-38,3	63,8	15,0	30,0	35,9	40,1	43,8	10,7	0,40	(-----*-----)
SxT	45	33,1	8,4	1,2	30,6-35,6	70,2	16,3	28,5	35,0	38,3	50,3	13,7	0,50	(--*---)
SxC	200	18,7	9,0	0,6	17,4-19,9	82,0	5,0	12,1	16,8	23,8	67,1	31,0	1,13	(-*)
SxA	60	17,7	8,1	1,0	15,6-19,8	65,3	2,1	11,9	15,6	24,5	40,1	22,5	0,82	(--*--)
CxA	27	25,9	8,8	1,7	22,4-29,3	76,9	6,4	20,2	25,9	31,4	45,5	20,6	0,75	(----*----)
TxA	20	28,1	10,5	2,3	23,2-33,0	109,6	7,3	19,6	28,6	35,8	48,2	28,2	1,03	(----*-----)
CxS	26	19,3	7,5	1,5	16,3-22,4	56,8	5,0	19,7	17,7	23,3	34,1	13,2	0,48	(----*---)
														---------+---------+---------+-------
														21,0 28,0 35,0

Continue

Table 3. Conclusion

Clone/hybrid	n	m	s	s(m)	CI	V	Min	Q_1	Median	Q_3	Max	CV%	b	Confidence Interval with t at 95% probability
								Production efficiency (kg/m³)						
T	32	19,0	4,4	0,8	17,4-20,6	19,4	12,4	16,2	18,8	20,7	31,8	23,1	-	(---*---)
S	48	9,8	3,9	0,6	8,7-10,9	15,3	1,5	7,3	9,4	11,5	21,4	39,8	-	(--*--)
C	47	15,9	3,4	0,5	14,9-16,9	11,6	9,1	13,5	15,8	17,8	23,5	21,4	-	(--*--)
TxS	16	20,0	5,9	1,5	16,9-23,2	34,5	6,4	17,4	21,0	23,5	29,9	21,6	0,77	(----*----)
SxT	45	21,0	7,8	1,2	18,6-23,3	60,5	8,2	14,9	20,6	26,5	36,8	31,8	1,13	(--*--)
SxC	200	8,7	5,3	0,4	8,0-9,5	28,0	2,0	5,2	7,0	11,2	40,1	40,7	1,45	(*-)
SxA	60	8,3	4,3	0,6	7,2-9,4	18,9	1,1	5,4	6,9	11,2	23,9	22,5	0,80	(--*-)
CxA	27	16,0	6,5	1,3	13,4-18,6	42,9	4,0	12,2	15,1	20,8	32,6	32,9	1,17	(---*---)
TxA	20	20,1	7,8	1,7	16,5-23,8	60,9	4,8	13,9	21,7	26,7	31,5	33,4	1,19	(----*----)
CxS	26	9,6	4,4	0,9	7,8-11,3	19,6	2,0	6,2	9,0	12,0	20,6	21,4	0,76	(---*---)
														-------+---------+---------+---------
														10,0 15,0 20,0
								Theoretical tonnage (ton/ha)						
T	32	133,6	30,9	5,5	122,5-144,8	956,9	38,8	117,2	135,3	152,7	298,0	23,1	-	(----*---)
S	48	112,6	40,3	5,8	100,9-124,3	1627,8	22,6	86,3	109,4	136,1	245,7	35,8	-	(---*--)
C	47	153,8	30,5	4,4	144,9-162,8	928,8	88,2	131,1	153,0	177,1	242,6	19,8	-	(---*---)
TxS	16	172,6	43,2	10,8	149,6-195,7	1868,3	85,2	140,8	168,9	216,0	232,1	153,	0,60	(------*-----)
SxT	45	160,9	37,7	5,6	149,6-172,2	1418,1	88,8	132,8	161,7	186,9	231,6	9,8	0,38	(---*---)
SxC	200	97,8	42,5	33,0	91,9-103,7	1805,1	27,1	66,0	90,0	120,1	282,9	26,2	1,00	(-*)
SxA	60	93,9	40,3	5,2	83,4-104,3	1626,0	10,6	64,2	84,9	123,3	188,9	23,1	0,88	(--*---)
CxA	27	123,7	40,8	7,8	107,6-139,8	1665,1	31,4	100,8	128,2	158,9	196,8	18,3	0,70	(----*----)
TxA	20	129,1	51,4	11,5	105,0-153,1	2640,1	36,1	85,3	130,1	157,0	231,5	30,4	1,16	(-----*-----)
CxS	26	97,4	35,9	7,0	82,9-111,9	1288,9	28,0	75,6	91,4	118,2	164,3	11,3	0,43	(----*-----)
														---+---------+---------+---------+---
														90 120 150 180

Industrial quality - Table 4 shows the results of the preliminary investigations in 1999 and 2002 as to the industrial quality of fruits from Valencia orange grafted on nine hybrids that are (Table 8) potentially more productive than Rangpur lime. The amplitudes of variation in the two harvests were generally in agreement and indicated that there was reasonable variability in the hybrids compared to the Rangpur lime reference. The parameters of greater variation amplitude in the two years were tritable acidity, Brix, TSS/TA ratio and soluble solids/box. Height, fruit width and juice yield were little influenced by the different hybrids. As these analyses were carried out on only one occasion in the two harvests, they are only indications and very dependent on the degree of ripening (Domingues et al., 1996; Blumer et al., 2003; Soares, 2005) and heat unit accumulation (Volpe, 1992) at the sampling date as shown by the differences in total acidity in the two years. However, differences in the Brix values of 19.8% to 20.2% greater than in Rangpur lime in three Trifoliate orange hybrids in two years may reflect, in part, real genetic variations. This possibility is plausible when three factors are considered: i) inducing high Brix is a known trait of the Trifoliate parent, ii) 16 TxS, 45 SxT and 20 TxA hybrids analyzed in 1999 by Bordignon et al. (2003_c) (Table 2) showed average Brix values superior to Rangpur lime and iii) in 2002 the ST 3502 hybrid presented Brix (that increases with ripening) 20% superior to Rangpur lime, although tritable acidity and vitamin C (that decreases with ripening) were also greater, 37% and 21%, respectively.

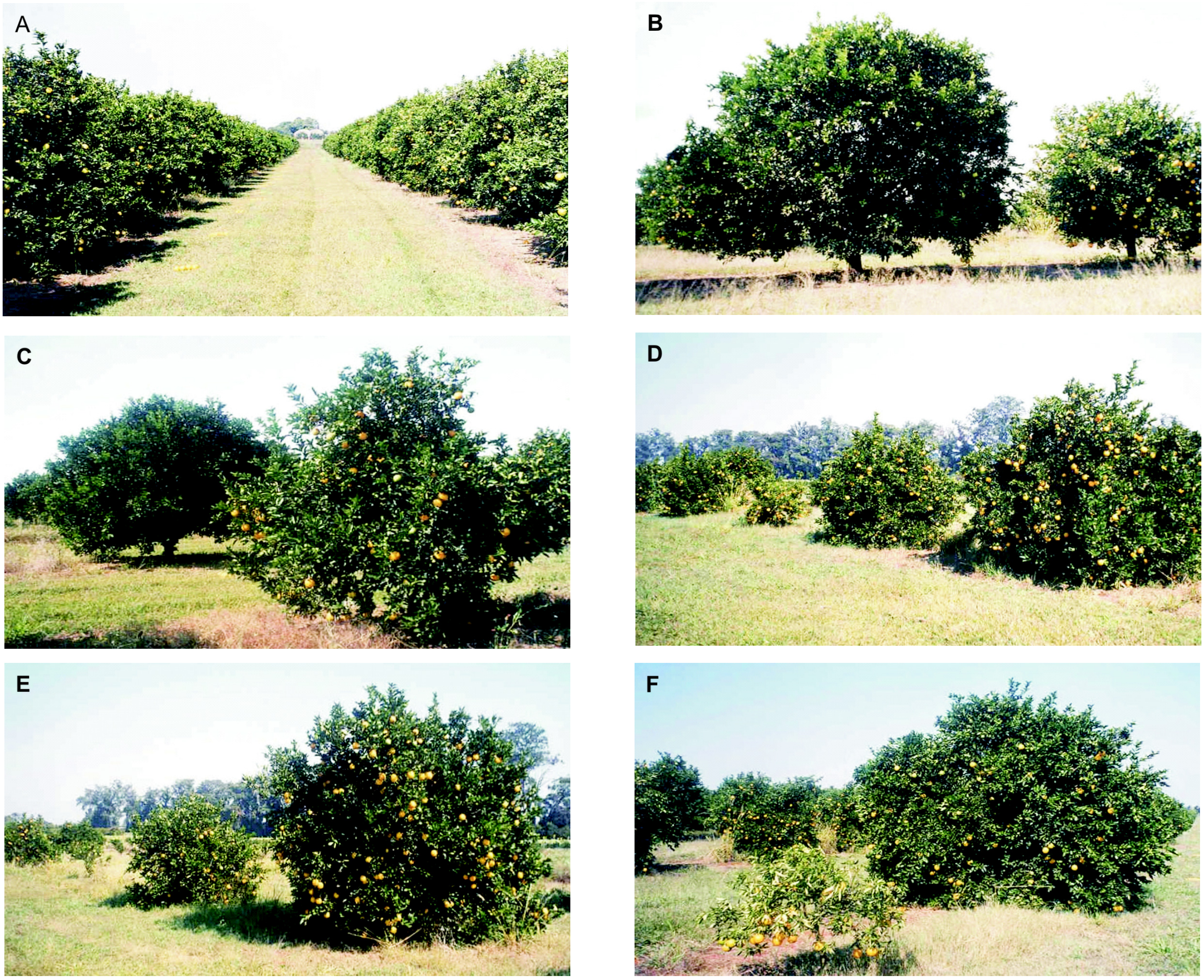

Figure 1. (A) Uniformity of the Valencia orange grafted on Rangpur lime (left) and Sunki mandarin (right) nucellars. **(B)**, **(C)**, **(D)**, **(E)** Variability for vigor, yield and **(F)** for CTV tolerance visualized in the Valencia orange trees grafted on different hybrids.

Table 4 . Preliminary analysis of the fruit weight (W), height (H), width (WD), height/width ratio (H/W), juice yield, total tritable acidity (TA), °Brix (°B), TSS/TA ratio (S/A), soluble solids/box (SS/B), fruits/box (F/B), vitamin C content in October 1999 and 2002 of Valencia orange bud grafted on a representative of Rangpur lime (C 2875) and on nine selected hybrids. S, C, T and A refer respectively to the Sunki mandarin, Rangpur lime, Trifoliate orange and Sour orange, parents of the identified hybrids. %C, var % and amp % refer respectively to the percentage of the hybrid compared to Rangpur lime, to the percentage variation for more or for less and the total amplitude of these percentages.

	1999																					
Identification	W g	%C	H	%C	WD cm	%C	H/W	%C	Juice %	%C	TA %	%C	°B	%C	S/A	%C	SS/B kg	%C	F/B n°	%C	Vit C mg	%C
C 2875	213	-	7,7	-	7,3	-	1,05	-	50,4	-	0,77	-	8,9	-	11,5	-	1,82	-	209	-	-	-
TS2195	218	+2,3	7,2	-6,5	7,0	-4,1	1,02	-2,8	53,6	+6,3	0,61	-20,8	8,3	-6,7	13,6	+18,3	1,82	0,0	219	+4,8	-	-
TS2192	225	+5,6	7,8	+1,3	7,0	-4,1	1,12	+6,7	52,7	+4,6	0,70	-9,1	9,2	+3,4	13,2	+14,8	1,99	+7,1	223	+6,7	-	-
TS1842	194	-8,9	7,3	-5,2	7,0	-4,1	1,05	0,0	54,1	+7,3	0,86	+11,7	10,7	+20,2	12,4	+7,8	2,35	+29,1	221	+5,7	-	-
TS2202	229	+7,5	7,7	0,0	7,3	0,0	1,05	0,0	48,3	-4,2	0,68	-11,7	8,7	-2,2	12,8	+11,3	1,72	-5,5	204	-2,4	-	-
ST2915	213	0,0	7,3	-5,2	6,7	-8,2	1,10	+4,8	48,5	-3,8	0,75	-2,6	10,7	+20,2	14,4	+25,2	2,13	+17,0	242	+15,8	-	-
ST3502	234	+9,8	7,7	0,0	7,3	0,0	1,05	0,0	51,6	+2,4	0,66	-14,3	9,6	+7,9	14,6	+26,9	2,03	+11,5	197	-5,7	-	-
SC3683	212	-0,5	7,8	+1,3	6,8	-6,8	1,15	+9,5	51,4	+2,0	0,82	+6,5	9,0	+1,1	10,9	-5,2	1,88	+3,3	221	+5,7	-	-
SC3944	231	+8,4	7,7	0,0	7,2	-1,4	1,07	+1,9	49,6	-1,6	0,68	-11,7	8,7	-2,2	12,8	+11,3	1,77	-2,7	209	0,0	-	-
SA3908	240	+12,7	7,7	0,0	7,3	0,0	1,05	0,0	49,1	-2,6	0,79	+2,6	8,6	-3,4	10,8	-6,1	1,72	-5,5	211	+0,9	-	-
Var(%)	**-8,9+12,7**		**-6,5+1,3**		**-8,2+0,0**		**-2,8+9,5**		**-4,2+7,3**		**-20,8+11,7**		**-6,7+20,2**		**-6,1+26,9**		**-5,5+29,1**		**-2,4+15,8**		**-**	
Amp(%)	**21,6**		**7,8**		**8,2**		**12,3**		**11,5**		**32,5**		**26,9**		**33,0**		**34,6**		**18,2**		**-**	

	2002																					
Identification	W g	%C	H	%C	WD cm	%C	H/W	%C	Juice %	%C	TA %	%C	°B	%C	S/A	%C	SS/B kg	%C	F/B n°	%C	Vit C mg	%C
C 2875	164,0	-	7,1	-	6,6	-	1,08	-	56,4	-	0,81	-	10,6	-	13,1	-	2,43	-	249	-	50,8	-
TS2195	174,5	+6,4	7,3	+2,8	6,8	+3,0	1,07	-0,9	56,2	-0,3	0,91	+12,3	10,6	0,0	11,6	-11,4	2,42	-0,4	234	-6,0	52,0	+2,4
TS2192	174,0	+6,1	7,3	+2,8	6,8	+3,0	1,08	0,0	57,2	+1,4	0,71	-12,3	9,6	-9,4	13,6	+3,8	2,25	-7,4	234	-6,0	49,4	-2,7
TS1842	161,5	-1,5	6,9	-2,8	6,6	0,0	1,05	-2,8	56,0	-0,7	0,93	+14,8	11,4	+7,5	12,2	-6,9	2,60	+7,0	253	+1,6	52,1	+2,6
TS2202	185,5	+13,0	7,2	+1,4	7,1	+7,6	1,01	-6,5	56,9	+0,9	0,80	-1,2	10,3	-2,8	12,8	-2,3	2,38	-2,0	220	-11,6	47,6	-6,3
ST2915	171,5	+4,6	7,3	+2,8	6,7	+1,5	1,09	+,09	56,9	+0,9	0,81	0,0	10,5	-0,9	13,0	-0,8	2,43	0,0	238	-4,4	57,1	+12,4
ST3502	169,0	+3,0	6,9	-2,8	6,8	+3,0	1,02	-5,5	57,4	+1,8	1,11	+37,0	12,7	+19,8	11,5	-12,2	2,98	+22,6	241	-3,2	61,5	+21,1
SC3683	170,5	+4,0	7,2	+1,4	6,7	+1,5	1,07	-0,9	54,3	-3,7	1,07	+32,1	10,7	+0,9	10,0	-23,7	2,37	-2,5	239	-4,0	55,2	+8,7
SC3944	175,0	+6,7	7,1	0,0	6,8	+3,0	1,04	-3,7	54,6	-3,2	1,22	+50,6	11,1	+4,7	9,5	-27,5	2,57	+5,8	233	-6,4	59,9	+17,9
SA3908	156,5	-4,6	7,2	+1,4	6,4	-3,0	1,12	+3,7	55,9	-0,9	1,00	+23,4	9,6	-9,4	9,8	-25,2	2,19	-9,9	261	+4,8	60,6	+19,3
Var(%)	**-4,6+13,1**		**-2,8+2,8**		**-3,0+7,6**		**-6,5+3,7**		**-3,7+1,8**		**-12,3+50,6**		**-9,4+19,8**		**-27,5+3,8**		**-9,9+22,6**		**-11,6+4,8**		**-6,3+21,1**	
Amp(%)	**17,7**		**5,6**		**10,6**		**10,2**		**5,5**		**62,9**		**29,2**		**31,3**		**32,5**		**16,4**		**27,4**	

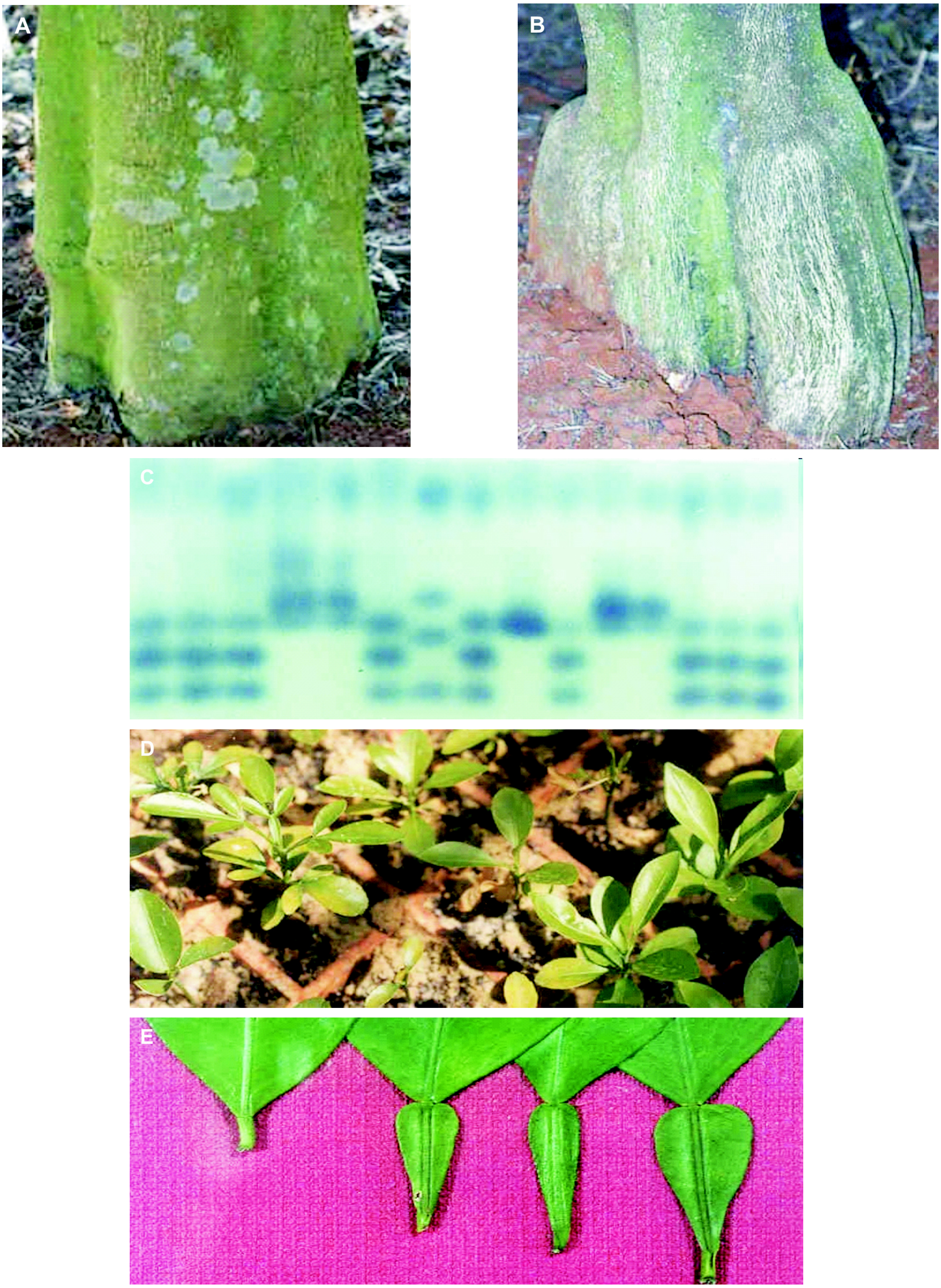

Figure 2. (A) Stock/scion congeniality of Valencia orange bud grafted on Sunki mandarin, Rangpur lime and their respective hybrids. **(B)** Formation of rootstock overgrowth at the bud union of Valência orange on Trifoliate or its hybrids. **(C)** Banding pattern of the genotypes FS, FS, FS, WF, WF, FS, WS, FS, FF, FS, WF, WF, FS, FS, FS of the *Pgi-1* locus. **(D)** Seedling with trifoliate (left) and unifoliate (others) leaf phenotype. **(E)** Variability for length and wing leaf petiole showing unwinged (left), semiwinged (center) and winged (right) phenotypes.

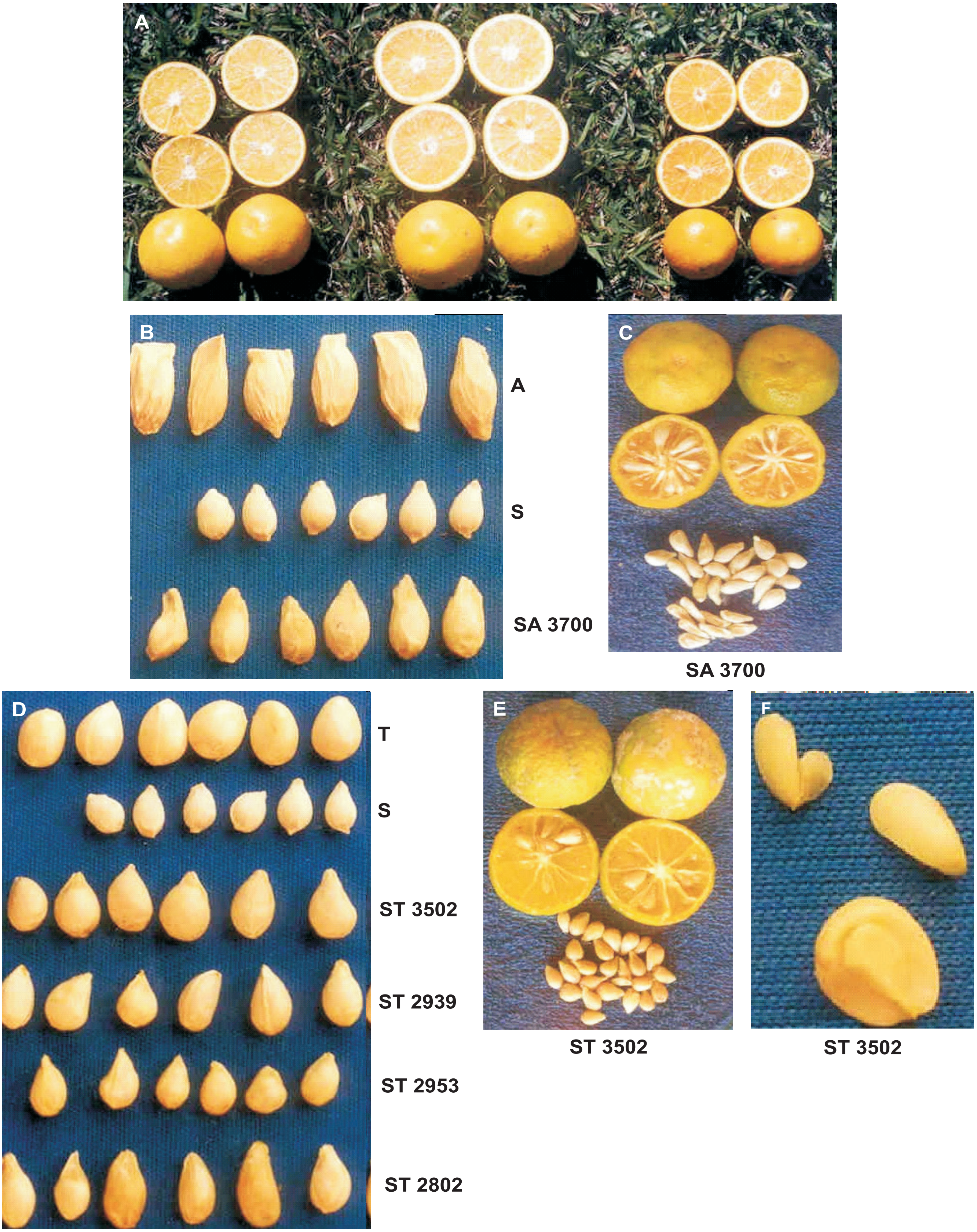

Figure 3. (A) Differences in the size, internal coloring and pericarp proportion in Valencia orange fruits from plants grafted on different rootstock hybrids. **(B)** Seeds of the Sour orange (A), Sunki mandarin (S) and the SA 3700 hybrid. **(C)** Fruits and viable (above) and aborted seeds (below) of the SA 3700 hybrid. **(D)** Trifoliate orange(T), Sunki mandarin (S) and seeds of SxT hybrids. **(E)** Fruits, seeds and **(F)** Polyembryony in a seed of ST 3502 hybrid.

Fruit traits of parents and hybrids - Table 5 shows the number of locules and seeds of fruits from the parents and 38 hybrids. The data corroborate the results of Carvalho et al. (1997) on these parent traits. The Sunki mandarin presented on average only 1.8 viable seeds per fruit contrasting with 10.8 viable seeds in Rangpur lime, 18 in Trifoliate orange and 34.7 in Sour orange. Trifoliate orange presented 6.6 and Sour orange 10.1 locules/fruit. Although the mean of this character was factors that include the pollen source and the activity of pollinators (Carvalho et al., 1997) but the results obtained suggested that most of the hybrids have normal seed production.

Table 5. Mean number of locules and seeds per fruit in the genitors Rangpur lime (C), Sunki mandarin (S), Sour orange (A), Trifoliate orange (T) and amplitude of variation of the means in 38 different CTV tolerant hybrids.

Genitors and hybrids	Hybrids	Fruits	Locules		Seeds	
			Variation	Mean	Variation	Mean
T	-	357	-	6.6	-	18.0
S	-	95	-	7.7	-	1.8
C	-	36	-	8.7	-	10.9
A	-	11	-	10.1	-	34.7
TxS	11	156	6.9-9.0	7.9	4.0-16.0	8.3
SxT	7	93	7.8-8.9	8.1	10.0-16.9	14.2
SxC	8	50	7.0-9.0	7.8	2.0-16.4	11.6
SxA	9	93	8.1-10.5	8.9	6.0-26.0	11.7
TxA	3	8	7.0-8.0	7.8	0.0-19.0	9.5
CxS	1	3	-	8.0	-	6.6
Total	**38**	**902**	**-**	**-**	**-**	**-**

Figure 3 shows seeds and fruits from some parents and hybrids. There were considerable variations among the 18 TxS and SxT hybrids studied more closely in the both the internal and external traits of the fruits, including seed size and shape. Thus, small orange colored fruits similar to those from Sunki mandarin and larger, yellowish green and septed fruits similar to those from Trifoliate orange were observed. Similarly to that observed by Soost and Cameron (1975), the marked odor of the Trifoliate orange exocarp could be identified in all fruits, but clear qualitative and quantitative sensory variations were perceived. Externally, the very marked Trifoliate orange lobed septa were clearly seen in some hybrids, but was almost imperceptible in others. There were also considerable variation in pericarp adherence, pulp coloring and seed size and shape. Some hybrids, for example, presented loose rind and orange colored pulp similar to Sunki mandarin while others had greenish yellow pulp and large seeds with a smooth testa as in Trifoliate orange, or with a longer micropilar portion of the testa, similar to Sunki mandarin. In eight of the nine SxA hybrids analyzed the fruit shape and external rind coloring were very similar to the Sunki mandarin parent, but some had adherent pericarp, similar to the Sour orange. Regarding the pulp, the odor was intermediate to the parents and the coloring varied over the parent extremes of creamy yellow and orange. The seeds also varied in size and shape, and most were large. The terminal micropilar portion of the testa varied from straight and wide as in Sour orange, to pointed, as in Sunki mandarin. The fruits of the three TxA hybrids presented greenish yellow external coloring and one of them had depressed lobes similar to Trifoliate orange. Their pulp coloring varied from creamy yellow as in Sour orange to greenish with the typical odor of the Trifoliate orange. The fruits observed in the CxS hybrid were similar to those of Rangpur lime for shape and odor and the seeds were also similar, but a little more rounded. Externally, the fruits of five of the eight SxC hybrids were similar to Sunki mandarin but the internal coloring and aroma were similar to Rangpur lime. The other three were internally and externally intermediate to the parents. The seeds of all these hybrids were more similar to Rangpur lime than to Sunki mandarin.

Descent uniformity - The analysis of the different hybrid groups showed their general differences. However, the values of the individuals belonging to each group are very important for breeding because in hybrids there is not only environmental variation, as in the clones, but also a genetic component. By simple selection of the hybrid, the genetic component becomes immediately fixed in its nucellar descent. Since the parents produce high percentages of nucellars, it would be expected (Cameron and Frost, 1968) that the hybrids would perform similarly. Indeed, the phenotypic analysis of a sample of 1800 plants referent to 25 progenies, including hybrids from the TxS, SxT, SxC, SxA and TxA groups, showed that 24 presented more than 75% uniform, probably nucellar, plants in the descent.

Genotypic variability - For most of the traits studied, the values of the genotypic variation coefficient (Table 6) were superior to those of variation due to the environment estimated by the parents. The b values were close or greater than one. This condition, according to Vencovsky (1978), is favorable to selection. Values greater than one were observed in the TxS, SxT and CxA hybrids for most of the traits. Coefficient b values of over 2.0 were detected for the SxA, TxA and CxS hybrids for the trait canopy shape and for hybrid congeniality of the TxS and TxA hybrids, showing the extreme variability of these hybrids for these traits. For the last trait the values were greater than one for all the crosses. Unlike to crosses involving Trifoliate orange, the SxC and SxA hybrids showed values lower than one for the b values in most of the traits. Negative values for the genotypic variance showed traits greatly influenced by the environment and with less genetic variability in proportional terms. Based on these parameters, the selection would be comparatively more efficient among the hybrids involving Trifoliate orange for most of the traits studied. Considering the group of hybrids and of nucellar clones it is observed that the mean genotypic effects were greater than the random effects of environment with cv_G% values superior to the cv_E% and b values of more than one for most of the traits assessed.

Table 6. Coefficient of the mean environmental variation in the parents (cv_E%), mean genotypic variation coefficients in their respective hybrids (cv_G%) and b indexes calculated by the cv_G% / cv_E% ratio referent to traits studied

Trait	cv_E%	cv_G%	b
Plant height (cm)	10.6	12.3	1.16
Canopy diameter (m)	12.4	10.9	0.88
Canopy shape	10.8	24.4	2.26
Canopy projection area (m^2)	22.9	21.9	0.95
Canopy volume (m^3)	29.6	33.8	1.14
Stock trunk diameter (cm)	11.1	15.0	1.35
Scion trunk diameter (cm)	12.3	14.1	1.14
Congeniality	6.8	16.3	2.39
Vigor	10.5	12.4	1.18
Mean fruit weight (g)	7.0	5.9	0.84
Accumulated yield (kg/plant)	27.6	31.4	1.14
Productivity (kg/m^2)	27.4	20.0	0.73
Production efficiency(kg/m^3)	28.1	29.2	1.04
Theoretical tonnage (ton/ha)	26.2	19.2	0.73

Selection potential - It is evident that no rootstock will be ideal for all situations, considering the biological and edafo-climatic diversities that interact with the canopy/ rootstock combinations and the large number of agroindustrial requirements. However, some general criteria are necessary to estimate the potential of the studied hybrids for selection purposes. Thus, for use in Brazil, any rootstock for sweet oranges and most other citrus must necessarily be CTV tolerant and give high yields and/ or productivity per area. Three hundred and ninety-four of the 534 hybrids were CTV tolerant. Table 7 shows a summary of yield parameters of the hybrids of each group studied after selection for CTV tolerance. Considering the individual value of each hybrid and the confidence intervals of the mean of the parents calculated with t at 95% confidence interval, it was verified that, of the tolerant hybrids, 173 (44%) induced individual yield greater than Trifoliate orange, 119 (30%) greater than Sunki mandarin and 75 (19%) greater than Rangpur lime. As to kg/m^2, 76 (19%) produced more than Trifoliate orange, 149 (38%) more than Sunki mandarin and 65 (16%) more than Rangpur lime. Regarding efficiency, 166 (42%) were more efficient than Sunki mandarin, 81 (21%) more efficient than Rangpur lime and 54 (14%) more efficient than Trifoliate orange. These results are in line with the levels of the three parameters of these three parents, because, as observed in Table 3, Trifoliate orange and Rangpur lime are, respectively, those with the smallest and greatest individual yield, but both induced greater productivity per area than Sunki mandarin. Trifoliate orange further presented greater efficiency per volume than Rangpur lime. Table 7 shows that the Trifoliate orange high productivity and efficiency traits were transmitted to its hybrids. The number of plants in the TxS, SxT and TxA groups, except for one case, decreased when the yield criterion was compared with the criteria productivity and production efficiency when the referential was Trifoliate orange, but always increased when the referentials were Sunki mandarin and Rangpur lime. This made them especially promising from the point of view of selection and suggested the potential of these hybrids is in the association of the Trifoliate orange productivity and efficiency with the vigor and robustness of Sunki mandarin and Sour orange. The number and percentage of hybrids sharply decreased in the SxC, SxA and CxS groups when those with higher yield were compared with those of greater productivity and production efficiency when the referential was Trifoliate orange, indicating that the high yield values in these groups were mostly proportional to the greater vegetative vigor of the hybrids.

Table 7. Number of hybrids planted and failures, number of CTV tolerant hybrids and of these, the number and respective percentages (in parenthesis) of hybrids according to the references accumulated yield (kg), productivity (kg/m^2) and production efficiency (kg/m^3) after seven cummulative harvests of Valencia orange grafted on them, calculated with t at 95% probability. Respectively, S, C, T, A refer to the Sunki mandarin, Rangpur lime, Trifoliate orange and Sour orange

	Number and (%) of hybrids							
	TxS	**SxT**	**SxC**	**SxA**	**CxA**	**TxA**	**CxS**	**Total**
Planted	20	67	207	98	48	65	29	**534**
Failures	4	8	7	11	16	13	3	**62**
CTV tolerants	16	45	200	60	27	20	26	**394**
Accumulated yield>T	12 (75)	34 (76)	81 (40)	24 (40)	11 (41)	5 (25)	6 (23)	**173 (44)**
Productivity>T	11 (69)	29 (64)	13 (6)	49 (82)	9 (33)	8 (40)	2 (8)	**121 (31)**
Production efficiency>T	9 (56)	22 (49)	3 (1)	2 (3)	7 (26)	11 (55)	0 (0)	**54 (14)**
Accumulated yield>S	9 (56)	24 (53)	51 (25)	20 (33)	5 (19)	5 (25)	5 (19)	**119 (30)**
Productivity>S	14 (88)	38 (84)	46 (23)	16 (27)	17 (63)	13 (65)	5 (19)	**149 (38)**
Production efficiency>S	14 (88)	40 (89)	50 (25)	15 (25)	21 (78)	17 (85)	9 (35)	**166 (42)**
Accumulated yield>C	7 (44)	16 (36)	30 (15)	12 (20)	4 (15)	4 (20)	2 (8)	**75 (19)**
Productivity>C	10 (62)	26 (58)	13 (6)	2 (3)	5 (19)	8 (40)	1 (4)	**65 (16)**
Production efficiency>C	13 (81)	29 (64)	12 (6)	2 (3)	12 (44)	12 (60)	1 (4)	**81 (21)**
Selected hybrids	**12 (75)**	**29 (64)**	**23 (11)**	**13 (22)**	**7 (26)**	**5 (25)**	**1 (4)**	**90 (23)**

Various criteria were used to select 90 (23%) of the 394 CTV tolerant hybrids. Table 8 shows their traits and potential compared to the Sunki mandarin, Rangpur lime, Trifoliate orange and Sour orange parents. Examples of isoenzymatic genotypes and leaf phenotypes of these hybrids are shown in Figure 2. The hybrids in the TxS and SxT groups are specially outstanding and were selected in proportionally greater percentages due to good yield performances and to their general reaction to *Phytophthora* . Whether by the results from trunk inoculation or from root infection, they formed a group of individuals generally superior to the Rangpur lime and some presented tolerance levels similar to Trifoliate orange. Results of Siviero (personal communication), using the needle test for gummosis in 10 nucellar seedlings corroborated those obtained in adult parent plants showing the Trifoliate orange resistance (0.65 mm lesion length), Sunki mandarin susceptibility (1.61 mm) while Rangpur lime was intermediate (0.96 mm). The only selected hybrid from this group that was tested, ST 2915, showed the lesion length close to Trifoliate orange (0.67mm). The last 24 hybrids (SxC and CxS) in Table 8 were included because in addition to being descent from the Sunki mandarin, whose potential is reported below, they all presented individual yield superior to the Trifoliate orange, Sunki mandarin and Rangpur lime. It should be pointed out, however, that they formed a separate group for which careful assessment of their reaction to *Phytophthora* is recommended because seven hybrids (not selected) tested by Medina Filho et al. (2004) were shown to be intolerant or highly intolerant to *Phytophthora* root rot. Two other SxC hybrids (not selected) tested for gummosis by Siviero (personal communication) were similar to Rangpur lime.

Final considerations - The investigations reported in the present study analyzed together show that the agroindustrial traits and performance induced by the Trifoliate orange, Sunki mandarin, Rangpur lime and Sour orange parents, ascertained by extensive experimentation and used as rootstocks in Brazilian citrus cropping, were widely corroborated by the data obtained. The study of the hybrids *per se* and their nucellar progenies or the Valencia orange canopies grafted on them showed, compared to the parents and by the most varied methods- genotypic and phenotypic analysis - the existence of considerable genetic variability, not only among the seven groups of hybrids analyzed, but also among the representatives of each group. Variability was detected in visual observations of the plants and their organs, quantitative trait measurements, quality analysis, genetic parameters and in the descriptive statistics. This variability suggests the correctness in the choice of the crosses carried out and the relevance of selecting hybrids that associate varied combinations of favorable traits present in the different parents. In November 2003, the plants were cut back to soil level and from the sprouting of these rootstocks five buds from each one of the 90 hybrids were grafted on Rangpur lime, introduced as new accessions in the Germplasm Collection of CACSM and field planted in November 2005. The selection of the 90 most promising hybrids represented only 23% of the 394 CTV tolerant hybrids, an index that could be more conservative provide this was the first selection and because remaining hybrids were eliminated. However, it is believed that this was adequate considering the absolute number of genotypes selected and that sequential selection or a single index was not adopted but rather selection was based on independent culling levels (Stonecypher, 1970) for various traits resulting in different percentuals within each hybrid group. The potential of the hybrids should be considered as a reference, since their nucellar progenies need to be assessed in extensive tests and under several plant health conditions. Because Sunki mandarin is tolerant to decline, sudden-death and the Capão Bonito CTV strain, it would be strategic that such investigations be also conducted in situations that permit assessment of these hybrids for tolerance to these factors. It would be important for citrus producers themselves, and of great value to citrus cropping science, if these investigations were carried out with representative participation of the main producing regions. Recently, an interesting modality of seedling has been experimented by Setin and Carvalho (2005) where nursery inarch is performed with an alternative rootstock for possible complementation of attributes of the two different rootstocks. By confirming the superiority of these plants, the advantages could be further extended using a combination of two hybrids of different species. Thus, up to four different rootstock species could participate simultaneously in each plant of the orchard, supposedly decreasing the biological vulnerability that results from the use of a single rootstock.

Table 8. Identification, genotypes and characteristics of the selected CTV tolerant hybrids introduced in the CACSM Germplasm Collection.

	Isoenzyme loci							Tristeza		Phytophthora					Accumulated yield								Height		Diameter	
Identification	*Pgi-1* *	*Pgm-1* *	*Got-1**	*Got-2* *,**	*Me-1*	*Aps-1****	*Prx$_a$-1*	*Az*****	*T*	Gummosis cm²	Reference	IR%	Classification	Leaf	kg/plant	Reference	kg/m²	Reference	kg/m³	Reference	ton/ha	Reference	cm	Reference	cm	Reference
Trifoliate	FS	PM	PM	SS.MT	RR	NN	FF	Az az	TT	2.7	-	3	AT	TS	153.9	-	28.6	-	19.0	-	134	-	227	-	258	-
Sunki	FF	FF	SS	FF.MM	II	CC	FM	Az az	tt	7.2	-	69	I	UN	183.2	-	21.6	-	9.8	-	113	-	337	-	335	-
Rangpur	FS	FF	FS	FS.MM	II	CC	MM	Az az	tt	5.8	-	36	T	UN	212.2	-	30.8	-	15.9	-	154	-	292	-	296	-
Sour	WS	FS	SS	FM.MM	II	CC	FS	Az az	TT	2.6	-	32	T	UA	-	-	-	-	-	-	-		-	-	-	-
TS 2195	FF	FP	MS	FS.MM	IR	CN	FF-FM	Az _	Tt	1.3	<T<C<S	-	-	TN	472.2	>T>S>C	41.6	>S>T>C	20.1	>S>C=T	232	>S>T>C	310	>T>C<S	380	>T>C>S
TS 2192	FF	FM	PS	FS.MT	IR	CN	FF-FM	Az _	Tt	1.5	<T<C<S	-	-	TN	449.0	>T>S>C	37.6	>S>T>C	17.1	>S>C<T	212	>S>T>C	330	>T>C=S	390	>T>C>S
TS 1842	FF	FM	MS	FS.MT	IR	CN	FF-FM	Az _	Tt	3.9	>T<C<S	30	T	TS	408.8	>T>S>C	42.5	>S>T>C	21.2	>S>C>T	229	>S>T>C	300	>T>C<S	350	>T>C>S
TS 2202	FS	FP	PS	FS.MT FS.MM	IR	CN	FF	Az _	Tt	5.3	>T=C=S	33	T	TS	407.9	>T>S>C	40.1	>S>T>C	18.2	>S>C=T	218	>S>T>C	330	>T>C=S	360	>T>C>S
ST 2915	FF FS	FP FM	PS MS	FS.MT FS.MM	IR	CN	FF-FM	Az _	Tt	2.8	=T<C<S	-	-	TN	398.0	>T>S>C	35.1	>S>T>C	15.0	>S=C<T	196	>S>T>C	350	>T>C>S	380	>T>C>S
SA 3908	FS	FF	SS	FF.MM	II	CC	FM	Az az	Tt	3.4	>T<C<S	-	-	US	381.3	>T>S>C	30.3	>S=T=C	11.7	>S<C<T	172	>S>T>C	390	>T>C>S	400	>T>C>S
ST 3294	FF FS	FP FM	PS FM	FS.MT FS.MM	IR	CN	FF-FM	Az _	Tt	2.7	=T<C<S	-	-	TN	376.0	>T>S>C	31.5	>S>T=C	13.1	>S<C<T	177	>S>T>C	360	>T>C>S	390	>T>C>S
TS 1774	FS	FP	MS	FS.MM	IR	CN	FF-FM	Az _	Tt	3.1	=T<C<S	36	T	TN	371.8	>T>S>C	31.1	>S>T=C	16.1	>S=C<T	175	>S>T>C	290	>T=C<S	390	>T>C>S
ST 3471	FF FS	FP FM	PS MS	FS.MT FS.MM	IR	CN	FF-FM	Az _	Tt	2.2	<T<C<S	-	-	TN	345.7	>T>S>C	40.5	>S>T>C	21.7	>S>C>T	212	>S>T>C	280	>T=C<S	330	>T>C=S
ST 2954	FF FS	FP FM	PS MS	FS.MT FS.MM	IR	CN	FF-FM	Az _	Tt	2.9	=T<C<S	-	-	TN	335.9	>T>S>C	40.7	>S>T>C	13.5	>S<C<T	165	>S>T>C	330	>T>C=S	380	>T>C>S
TA 1884	FS	FP	PS	FS.MT	IR	CN	FF	Az az	TT	6.1	>T=C=S	-	-	TA	327.0	>T>S>C	26.0	>S<T<C	25.3	>S>C>T	211	>S>T>C	240	>T<C<S	320	>T>C<S
ST 3298	FF FS	FP FM	PS MS	FS.MT FS.MM	IR	CN	FF-FM	Az _	Tt	1.1	<T<C<S	-	-	TS	311.6	>T>S>C	40.0	>S>T>C	20.6	>S>C=T	206	>S>T>C	290	>T=C<S	315	>T>C<S
CA 3875	FS	FF	FS	FS.MM	II	CC	MS	Az az	Tt	2.9	=T<C<S	-	-	UN	307.8	>T>S>C	33.0	>S>T>C	15.5	>S=C<T	176	>S>T>C	320	>T>C<S	345	>T>C=S
ST 3448	FF FS	FP FM	FS MS	FS.MT FS.MM	IR	CN	FF-FM	Az _	Tt	2.4	=T<C<S	13	AT	TS	302.3	>T>S>C	45.8	>S>T>C	25.4	>S>C>T	227	>S>T>C	270	>T<C<S	290	>T=C<S

Continue

Table 8. Continuation

Identification	Isoenzyme loci							Tristeza		Phytophthora				Leaf	Accumulated yield								Height		Diameter	
	Pgi-1 *	*Pgm-1* *	*Got-1**	*Got-2* *,**	*Me-1*	*Aps-1****	*Prx_a-1*	*Az*****	*T*	Gummosis cm²	Reference	IR%	Classification		kg/plant	Reference	kg/m²	Reference	kg/m³	Reference	ton/ha	Reference	cm	Reference	cm	Reference
SA 3384	FS	FF FS	-	FF.MM FM.MM	II	CC	FM	Az az	Tt	2.0	<T<C<S	19	AT	U	293.1	>T>S>C	25.8	>S<T<C	10.2	=S<C<T	144	>S=T<C	380	>T>C>S	380	>T>C>S
ST 3502	FF FS	FP FM	FS MS	FS.MT FS.MM	IR	CN	FF-FM	Az _	Tt	1.5	<T<C<S	37	T	TN	292.1	>T>S>C	47.5	>S>T>C	26.2	>S>C>T	232	>S>T>C	270	>T<C<S	280	>T<C<S
TS 2199	FF	FP	PS	FS.MT	IR	CN	FF	Az _	Tt	2.3	=T<C<S	-	-	TN	289.4	>T>S>C	43.8	>S>T>C	21.9	>S>C>T	195	>S>T>C	300	>T>C<S	290	>T=C<S
SA 3745	FS	FF	-	FF.MM FM.MM	II	CC	FM	Az az	Tt	4.5	>T=C<S	-	-	UA	285.1	>T>S>C	20.6	=S<T<C	7.7	<S<C<T	119	=S<T<C	400	>T>C>S	420	>T>C>S
TS 2191	FS	FP	PS MS	FS.MT	IR	CN	FF-FM	Az _	Tt	2.8	=T<C<S	-	-	TS	282.5	>T>S>C	37.5	>S>T>C	20.0	>S>C=T	191	>S>T>C	280	>T<C>S	310	>T>C<S
TA 2509	FS	PS	MS	FS.MT MS.MT FS.MM MS.MM	IR	CN	FF	Az az	TT	1.1	<T<C<S	-	-	TA	276.3	>T>S>C	48.3	>S>T>C	30.4	>S>C>T	231	>S>T>C	240	>T<C<S	270	=T<C<S
SA 3718	FS	FF	-	FM.MM	II	CC	FF	Az az	Tt	6.0	>T=C=S	45	MT	US	271.9	>T>S>C	25.3	>S<T<C	10.8	=S<C<T	139	>S=T<C	350	>T>C>S	370	>T>C>S
SA 3898	FS	FS	-	FF.MM FM.MM	II	CC	FF	Az az	Tt	5.8	>T=C=S	-	-	UA	270.6	>T>S>C	25.2	>S<T<C	11.8	>S<C<T	139	>S=T<C	320	>T>C<S	370	>T>C>S
ST 3507	FF FS	FP FM	PS MS	FS.MT FS.MM	IR	CN	FF-FM	Az _	Tt	2.5	=T<C<S	-	-	TN	258.9	>T>S>C	28.5	>S=T<C	14.8	>S<C<T	152	>S>T=C	290	>T=C<S	340	>T>C=S
TA 1965	SS	FM	MS	FS.MM	IR	CN	FF	Az az	TT	2.0	<T<C<S	-	-	TS	258.4	>T>S>C	42.0	>S>T>C	26.1	>S>C>T	205	>S>T>C	240	>T<C<S	280	>T<C<S
SA 3738	FS	FF	-	FF.MM	II	CC	MM	Az az	Tt	1.6	<T<C<S	-	-	UA	256.4	>T>S>C	28.2	>S=T<C	13.7	>S<C<T	150	>S>T=C	310	>T>C<S	340	>T>C=S
ST 2911	FF FS	FP FM	PS MS	FS.MT FS.MM	IR	CN	FF-FM	Az _	Tt	3.7	>T<C<S	38	T	TN	253.9	>T>S>C	41.3	>S>T>C	25.6	>S>C>T	201	>S>T>C	240	>T<C<S	280	>T<C<S
ST 2941	FF FS	FP FM	PS MS	FS.MT FS.MM	IR	CN	FF-FM	Az _	Tt	4.0	>T<C<S	-	-	TN	252.9	>T>S>C	29.6	>S=T=C	15.9	>S=C<T	155	>S>T=C	280	>T<C<S	330	>T>C=S
ST 3376	FF FS	FP FM	PS MS	FS.MT FS.MM	IR	CN	FF-FM	Az _	Tt	3.1	=T<C<S	-	-	TN	252.6	>T>S>C	44.2	>S>T>C	26.6	>S>C>T	211	>S>T>C	250	>T<C<S	270	=T<C<S
SA 3386	FS	FF	-	FM.MM	II	CC	MS	Az az	Tt	1.9	<T<C<S	-	-	U	249.0	>T>S>C	27.4	>S=T<C	12.1	>S<C<T	146	>S>T=C	340	>T>C=S	340	>T>C=S
ST 3378	FF FS	FP FM	PS MS	FS.MT FS.MM	IR	CN	FF-FM	Az _	Tt	1.3	<T<C<S	-	-	TN	247.7	>T>S>C	32.9	>S>T>C	17.6	>S>C=T	168	>S>T>C	280	>T<C<S	310	>T>C<S

Continue

Table 8. Continuation

Identification	Isoenzyme loci							Tristeza		Phytophthora				Leaf	Accumulated yield								Height		Diameter	
	Pgi-1 *	*Pgm-1* *	*Got-1**	*Got-2* *,**	*Me-1*	*Aps-1****	*Prx$_a$-1*	*Az*****	*T*	Gummosis cm^2	Reference	IR%	Classification		kg/plant	Reference	kg/m^2	Reference	kg/m^3	Reference	ton/ha	Reference	cm	Reference	cm	Reference
ST 3447	FF FS	FP FM	PS MS	FS.MT FS.MM	IR	CN	FF-FM	Az _	Tt	8.5	>T>C=S	-	-	TS	247.1	>T>S>C	50.3	>S>T>C	32.9	>S>C>T	233	>S>T>C	230	=T<C<S	250	=T<C<S
SA 3397	FS	FF	-	FF.MM	II	CC	FF	Az az	Tt	5.9	>T=C=S	-	-	UA	245.5	>T>S>C	20.6	=S<T<C	8.1	<S<C<T	116	=S<T<C	380	>T>C>S	390	>T>C>S
ST 2926	FF FS	FP FM	PS MS	FS.MT FS.MM	IR	CN	FF-FM	Az _	Tt	2.3	=T<C<S	-	-	TN	242.6	>T>S>C	36.8	>S>T>C	22.9	>S>C>T	182	>S>T>C	240	>T<C<S	290	>T=C<S
SA 3135	FS	FS	-	FF.MM FM.MM	II	CC	FS	Az az	Tt	2.5	=T<C<S	-	-	UA	241.1	>T>S>C	19.2	=S<T<C	7.4	<S<C<T	109	=S<T<C	390	>T>C>S	400	>T>C>S
SA 3732	FS	FF	-	FF.MM	II	CC	FF	Az az	Tt	2.7	=T<C<S	-	-	UA	237.6	>T>S>C	31.5	>S>T=C	14.8	>S<C<T	161	>S>T=C	320	>T>C<S	310	>T>C<S
CA 3838	FS	FF	SS	MS.MM	II	CC	MS	Az az	Tt	2.0	<T<C<S	-	-	UA	237.2	>T>S>C	31.5	>S>T=C	18.1	>S>C=T	161	>S>T=C	260	>T<C<S	310	>T>C<S
CA 3854	WF	FS	SS	FM.MM	II	CC	MS	Az az	Tt	3.2	>T<C<S	-	-	UA	234.3	>T>S>C	31.1	>S>T=C	15.0	>S=C<T	159	>S>T=C	310	>T>C<S	310	>T>C<S
ST 2947	FF FS	FP FM	PS MS	FS.MT FS.MM	IR	CN	FF-FM	Az _	Tt	1.4	<T<C<S	-	-	TN	234.0	>T>S>C	18.6	<S<T<C	8.2	<S<C<T	106	=S<T<C	340	>T>C=S	400	>T>C>S
SA 3759	WF	FF	-	FF.MM FM.MM	II	CC	FM	Az az	Tt	7.5	>T>C=S	-	-	US	233.0	>T>S>C	25.7	>S<T<C	11.7	>S<C<T	137	>S=T<C	330	>T>C=S	340	>T>C=S
TA 1966	WS	-	PS	FS.MT MS.MT FS.MM MS.MM	IR	CN	FF	Az az	TT	4.0	>T<C<S	-	-	TA	230.7	>T>S>C	30.6	>S=T=C	15.8	>S=C<T	156	>S>T=C	290	>T=C<S	310	>T>C<S
TS 1777	FF FS	FP FM	MS	FS.MT FS.MM	IR	CN	FF-FM	Az _	Tt	2.2	<T<C<S	10	-	TS	226.1	>T>S=C	20.0	=S<T<C	9.3	=S<C<T	102	=S<T<C	320	>T>C<S	380	>T>C>S
ST 2945	FF FS	FP FM	PS MS	FS.MT FS.MM	IR	CN	FF-FM	Az _	Tt	2.9	=T<C<S	-	-	TN	226.0	>T>S=C	18.0	<S<T<C	8.2	<S<C<T	106	=S<T<C	330	>T>C=S	400	>T>C>S
ST 2937	FS	FP	PS	FS.MT FS.MM	IR	CN	FF	Az _	Tt	3.2	>T<C<S	-	-	TS	218.3	>T>S=C	35.5	>S>T>C	20.4	>S>C=T	173	>S>T>C	260	>T<C<S	280	>T<C<S
ST 2950	FF FS	FP FM	PS MS	FS.MT FS.MM	IR	CN	FF-FM	Az _	Tt	-	-	-	-	TN	215.8	>T>S=C	40.6	>S>T>C	22.7	>S>C>T	191	>S>T>C	270	>T<C<S	260	=T<C<S
SA 3754	WF	FS	SS	FF.MM	II	CC	MS	Az az	Tt	5.5	>T=C=S	12	-	UA	213.6	>T>S=C	28.3	>S=T<C	14.1	>S<C<T	145	>S>T=C	300	>T>C<S	310	>T>C<S
SA 3711	WF	FS	-	FM.MM	II	CC	MS	Az az	Tt	2.4	=T<C<S	40	-	UA	212.9	>T>S=C	40.1	>S>T>C	21.5	>S>C>T	189	>S>T>C	280	>T<C<S	260	=T<C<S

Continue

Table 8. Continuation

Identification	Isoenzyme loci							Tristeza		Phytophthora				Leaf	Accumulated yield								Height		Diameter	
	Pgi-1 *	*Pgm-1* *	*Got-1**	*Got-2* *,**	*Me-1*	*Aps-1****	*Prx$_a$-1*	*Az*****	*T*	Gummosis cm²	Reference	IR%	Classification		kg/plant	Reference	kg/m²	Reference	kg/m³	Reference	ton/ha	Reference	cm	Reference	cm	Reference
TS 2201	FF	FP	PS	FS.MT	IR	CN	FM	Az _	Tt	1.5	<T<C<S	-	-	TN	212.6	>T>S=C	40.1	>S>T>C	29.9	>S>C>T	189	>S>T>C	200	<T<C<S	260	=T<C<S
ST 2918	FF FS	FP FM	PS MS	FS.MT FS.MM	IR	CN	FF-FM	Az _	Tt	5.5	>T=C=S	-	-	TN	210.7	>T>S=C	36.8	>S>T>C	23.9	>S>C>T	176	>S>T>C	230	=T<C<S	270	=T<C<S
ST 2939	FF FS	FP FM	PS MS	FS.MT FS.MM	IR	CN	FF-FM	Az _	Tt	2.9	=T<C<S	-	-	TN	210.3	>T>S=C	36.7	>S>T>C	23.1	>S>C>T	176	>S>T>C	240	>T<C<S	270	=T<C<S
ST 3501	FF FS	FP FM	PS MS	FS.MT FS.MM	IR	CN	FF-FM	Az _	Tt	1.3	<T<C<S	26	-	TS	209.4	>T>S=C	40.3	>S>T>C	34.9	>S>C>T	209	>S>T>C	200	<T<C<S	240	<T<C<S
CA 3266	FS	FS	FS	FS.MM MS.MM FF.MM FM.MM	II	CC	MS	Az az	Tt	1.4	<T<C<S	-	-	US	206.2	>T>S=C	36.1	>S>T>C	21.7	>S>C>T	139	>S=T<C	250	>T<C<S	270	=T<C<S
ST 2985	FF FS	FP FM	PS MS	FS.MT FS.MT	IR	CN	FF-FM	Az _	Tt	6.0	>T=C=S	-	-	TN	199.1	>T=S=C	37.5	>S>T>C	24.6	>S>C>T	177	>S>T>C	230	=T<C<S	260	=T<C<S
ST 3141	FF FS	FP FM	PS MS	FS.MT FS.MT	IR	CN	FF-FM	Az _	Tt	2.8	=T<C<S	-	-	TS	196.7	>T=S<C	37.1	>S>T>C	17.9	>S>C=T	174	>S>T>C	310	>T>C<S	260	=T<C<S
ST 3147	FF FS	FP FM	PS MS	FS.MT FS.MM	IR	CN	FF-FM	Az _	Tt	4.2	>T<C<S	-	-	TN	196.0	>T=S<C	36.9	>S>T>C	29.3	>S>C>T	174	>S>T>C	190	<T<C<S	260	=T<C<S
CA 3851	WF	FF	SS	FM.MM	II	CC	MS	Az az	Tt	12.5	>T>C>S	-	-	UN	194.8	>T=S<C	40.0	>S>T>C	22.0	>S>C>T	184	>S>T>C	270	>T<C<S	250	=T<C<S
TS 2211	FF	FP FM	PS MS	FS.MM	IR	CN	FF-FM	Az _	Tt	3.3	>T<C<S	-	-	TS	181.0	>T=S<C	34.1	>S>T>C	23.2	>S>C>T	161	>S>T=C	220	=T<C<S	260	=T<C<S
CA 3185	WF	FS	FS	FS.MM MS.MM FF.MM FM.MM	II	CC	MS	Az az	Tt	2.4	=T<C<S	-	-	UA	173.0	>T=S<C	45.5	>S>T>C	32.6	>S>C>T	197	>S>T>C	210	<T<C<S	220	<T<C<S
ST 2802	FF FS	FP FM	PS MS	FS.MT FS.MM	IR	CN	FF-FM	Az _	Tt	1.8	<T<C<S	-	-	TN	170.9	>T=S<C	35.0	>S>T>C	24.9	>S>C>T	162	>S>T=C	210	<T<C<S	250	=T<C<S
TS 2203	FS	FP FM	MS	FS.MT FS.MM	IR	CN	FM	Az _	Tt	1.8	<T<C<S	-	-	TN	158.9	=T<S<C	35.1	>S>T>C	26.5	>S>C>T	159	>S>T=C	200	<T<C<S	240	<T<C<S
CA 3165	SS	FF	FS	FS.MM MS.MM FM.MM FM.MM	II	CC	FM	Az az	Tt	11.4	>T>C>S	-	-	UN	153.4	=T<S<C	36.9	>S>T>C	25.1	>S>C>T	163	>S>T>C	220	=T<C<S	230	<T<C<S

Continue

Table 8. Continuation

	Isoenzyme loci							Tristeza		Phytophthora					Accumulated yield								Height		Diameter	
Identification	*Pgi-1* *	*Pgm-1* *	*Got-1**	*Got-2* *,**	*Me-1*	*Aps-1****	*Prx$_a$-1*	*Az*****	*T*	Gummosis cm^2	Reference	IR%	Classification	Leaf	kg/plant	Reference	kg/m^2	Reference	kg/m^3	Reference	ton/ha	Reference	cm	Reference	cm	Reference
TS 2182	FF	FP FM	PS	FS.MT FS.MM	IR	CN	FM	Az _	Tt	2.6	=T<C<S	-	-	TS	152.5	=T<S<C	36.8	>S>T>C	23.8	>S>C>T	162	>S>T=C	210	<T<C<S	230	<T<C<S
ST 3499	FF FS	FP FM	PS MS	FS.MT FS.MM	IR	CN	FF-FM	Az _	Tt	1.4	<T<C<S	-	-	TN	151.7	=T<S<C	40.0	>S>T>C	31.6	>S>C>T	173	>S>T>C	190	<T<C<S	220	<T<C<S
TA 1911	FS	MS	PS	FS.MT MS.MT FS.MM MS.MM	IR	CN	FF-FS	Az az	TT	2.2	<T<C<S	-	-	TA	150.0	=T<S<C	36.1	>S>T>C	28.3	>S>C>T	160	>S>T=C	190	<T<C<S	230	<T<C<S
ST 3446	FF FS	FP FM	PS MS	FS.MT FS.MM	IR	CN	FF-FM	Az _	Tt	1.0	<T<C<S	-	-	TN	140.3	=T<S<C	33.8	>S>T>C	28.1	>S>C>T	149	>S>T=C	180	<T<C<S	230	<T<C<S
ST 2817	FF FS	FP FM	PS MS	FS.MT FS.MM	IR	CN	FF-FM	Az _	Tt	2.0	<T<C<S	-	-	TS	121.7	<T<S<C	35.2	>S>T>C	26.5	>S>C>T	148	>S>T=C	200	<T<C<S	210	<T<C<S
ST 3150	FF FS	FP FM	PS MS	FS.MT FS.MM	IR	CN	FF-FM	Az _	Tt	2.7	=T<C<S	-	-	TN	99.4	<T<S<C	39.1	>S>T>C	36.8	>S>C>T	151	>S>T=C	160	<T<C<S	180	<T<C<S
SC 3325	FF	FF	SS	-	II	CC	MM	_ _	tt	2.6	=T<C<S	-	-	UN	347.2	>T>S>C	36.1	>S>T>C	14.2	>S<C<T	194	>S>T>C	380	>T>C>S	350	>T>C>S
SC 3574	FF	FF	FS	-	II	CC	MM	_ _	tt	3.8	>T<C<S	-	-	UN	326.4	>T>S>C	26.0	>S<T<C	9.7	=S<C<T	148	>S>T=C	400	>T>C>S	400	>T>C>S
SC 3817	FF	FF	SS	-	II	CC	MM	_ _	tt	8.2	>T>C=S	-	-	UN	322.3	>T>S>C	40.1	>S>T>C	20.0	>S>C=T	208	>S>T>C	300	>T>C<S	320	>T>C=S
SC 3629	FF	FF	SS	-	II	CC	MM	_ _	tt	3.0	=T<C<S	-	-	UN	315.7	>T>S>C	36.9	>S>T>C	16.3	>S=C<T	194	>S>T>C	340	>T>C=S	330	>T>C=S
SC 3683	FF	FF	FS	FS.MM	II	CC	FM	_ _	tt	6.2	>T=C=S	-	-	UN	305.0	>T>S>C	46.2	>S>T>C	24.8	>S>C>T	229	>S>T>C	280	>T<C<S	290	>T=C<S
SC 3950	FF	FF	SS	-	II	CC	FM	_ _	tt	7.7	>T>C=S	-	-	UN	303.5	>T>S>C	29.9	>S=T=C	15.4	>S=C<T	163	>S>T>C	290	>T=C<S	360	>T>C>S
SC 3811	FF	FF	FS	-	II	CC	FM	_ _	tt	2.0	<T<C<S	-	-	UN	298.4	>T>S>C	29.3	>S=T=C	11.9	>S<C<T	160	>S>T=C	370	>T>C>S	360	>T>C>S
SC 3947	FF	FF	FS	-	II	CC	FM	_ _	tt	2.4	=T<C<S	-	-	UN	298.1	>T>S>C	34.8	>S>T>C	15.4	>S=C<T	183	>S>T>C	340	>T>C=S	330	>T>C=S
SC 3324	FF	FF	SS	-	II	CC	MM	_ _	tt	6.9	>T=C=S	-	-	UN	293.8	>T>S>C	41.6	>S>T>C	19.0	>S>C=T	209	>S>T>C	330	>T>C=S	300	>T=C<S
SC 3944	FF	FF	SS	-	II	CC	MM	_ _	tt	4.4	>T<C<S	-	-	UN	290.6	>T>S>C	41.1	>S>T>C	19.9	>S>C=T	207	>S>T>C	310	>T>C=S	300	>T=C<S
SC 3321	FF	FF	SS	-	II	CC	MM	_ _	tt	4.8	>T=C<S	-	-	UN	287.2	>T>S>C	38.0	>S>T>C	17.3	>S>C<T	195	>S>T>C	330	>T>C=S	310	>T>C=S
SC 3941	FS	FF	SS	-	II	CC	FM	_ _	tt	6.4	>T=C=S	-	-	UN	279.8	>T>S>C	30.8	>S=T=C	15.0	>S=C<T	164	>S>T>C	310	>T>C=S	340	>T>C=S

Continue

Table 8. Conclusion

Identification	Isoenzyme loci							Tristeza		Phytophthora				Leaf	Accumulated yield								Height		Diameter	
	Pgi-1 *	*Pgm-1* *	*Got-1**	*Got-2* *,**	*Me-1*	*Aps-1****	*Prx_a-1*	*Az*****	*T*	Gummosis cm²	Reference	IR%	Classification		kg/plant	Reference	kg/m²	Reference	kg/m³	Reference	ton/ha	Reference	cm	Reference	cm	Reference
SC 3917	FS	FF	SS	-	II	CC	FM	_ _	tt	2.0	<T<C<S	-	-	UN	275.7	>T>S>C	28.6	>S=T<C	13.1	>S<C<T	154	>S>T=C	330	>T>C=S	350	>T>C>S
SC 3316	FS	FF	SS	-	II	CC	MM	_ _	tt	2.8	=T<C<S	-	-	UN	263.3	>T>S>C	25.9	>S<T<C	11.8	>S<C<T	141	>S=T<C	330	>T>C=S	360	>T>C>S
SC 3605	FF	FF	SS	-	II	CC	FM	_ _	tt	3.2	>T<C<S	-	-	UN	261.1	>T>S>C	27.1	>S=T<C	11.3	>S<C<T	146	>S>T=C	360	>T>C>S	350	>T>C>S
SC 3674	FF	FF	SS	FS.MM	II	CC	MM	_ _	tt	2.1	<T<C<S	-	-	UN	257.1	>T>S>C	20.5	=S<T<C	8.8	=S<C<T	116	=S<T<C	350	>T>C>S	400	>T>C>S
SC 3587	FF	FF	FS	-	II	CC	FM	_ _	tt	6.1	>T=C=S	-	-	UN	255.8	>T>S>C	25.1	>S<T<C	10.5	=S<C<T	137	>S=T<C	360	>T>C>S	360	>T>C>S
SC 3617	FF	FF	SS	-	II	CC	MM	_ _	tt	2.3	=T<C<S	-	-	UN	248.4	>T>S>C	21.9	=S<T<C	8.7	=S<C<T	122	=S<T<C	380	>T>C>S	380	>T>C>S
SC 3591	FF	FF	SS	-	II	CC	MM	_ _	tt	4.2	>T<C<S	-	-	UN	247.5	>T>S>C	18.7	<S<T<C	7.0	<S<C<T	108	=S<T<C	400	>T>C>S	410	>T>C>S
SC 3654	FF	FF	FS	FS.MM	II	CC	MM	_ _	tt	1.1	<T<C<S	-	-	UN	244.4	>T>S>C	19.5	=S<T<C	8.3	<S<C<T	111	=S<T<C	350	>T>C>S	400	>T>C>S
SC 3948	FF	FF	FS	-	II	CC	MM	_ _	tt	1.5	<T<C<S	-	-	UN	239.2	>T>S>C	26.3	>S=T<C	11.6	>S<C<T	140	>S=T<C	340	>T>C=S	340	>T>C=S
SC 3785	FF	FF	SS	-	II	CC	MM	_ _	tt	3.1	=T<C<S	-	-	UN	235.7	>T>S>C	24.5	>S<T<C	11.8	>S<C<T	132	>S=T<C	310	>T>C=S	350	>T>C>S
SC 3931	FF	FF	FS	-	II	CC	MM	_ _	tt	2.0	<T<C<S	-	-	UN	232.3	>T>S>C	67.1	>S>T>C	40.1	>S>C>T	283	>S>T>C	250	>T<C<S	210	<T<C<S
CS 4264	FS	FF	SS	FS.MM	II	CC	MM	_ _	tt	5.1	>T=C=S	-	-	UN	230.4	>T>S>C	32.6	>S>T=C	16.8	>S=C<T	164	>S>T>C	290	>T=C<S	300	>T=C<S

Obs: Initials denote their parent rootstocks Trifoliate orange (T), Sunki mandarin (S), Rangpur lime (C) and Sour orange (A). It is indicated genotypes of seven isoenzymatic loci, of the two loci that determine CTV tolerance, leaf phenotypes (T= trifoliolate; U= unifoliolate; A= winged petiole; N= unwinged petiole; S= semi-winged petiole), canopy height and diameter in cm, mean gummosis lesion area in cm^2 in two trunk inoculations on adult plants, total growth reduction index (IR%) due to *Phytophthora* root infection in nucellar progeny seedlings and the corresponding classification as highly tolerant (AT), tolerant (T), moderately tolerant (MT) or intolerant (I), accumulated yield of seven years of the Valencia orange canopy in kg/plant, productivity in kg/m^2 of the canopy projection, production efficiency in kg/m^3 of canopy, theoretical tonnage in ton/ha. The selection potential of each hybrid is indicated as determined by various criteria having as reference the confidence interval of the mean of the parents with t at 95% probability, either greater (>), smaller (<) or equal (=) to the indicated criteria. Except for IR% values that refer to the means of the nucellar progenies of the hybrids, the others refer to means of the parents and to the individual values of each hybrid.

* includes alternative genotype(s), ** . separates the duplicate loci, *** N corresponds to the null allele, **** _ indicates the Az or az allele

4. CONCLUSIONS

1. The study of the hybrids *per se* or the Valencia orange canopies grafted on them showed marked variation among the seven groups of hybrids studied and among the representatives of each group.

2. Considerable genetic variability in the hybrids was detected by studies of quantitative and qualitative traits, genotypic and phenotypic analyses, genetic parameter values, descriptive statistics and visual observation of the plants and their organs.

3. Estimates of genetic parameters (cv_G% and b) for 14 traits showed greater mean genetic than environmental effects in the hybrids. For most of the traits assessed, the Trifoliate orange hybrids presented the greatest deviations from the general mean because of genotypic effects.

4. The Sunki mandarin conferred greater vegetative vigor to the Valencia orange canopies than Trifoliate orange while Rangpur lime presented intermediate performance. The SxC, SxA and CxS hybrids, similarly to Sunki mandarin, induced great vegetative vigor to the canopies. The canopies presented, on average, reduced vigor in the TxS, SxT, CxA and TxA hybrids although in some genotypes it was more similar to that in one or another parent.

5. The formation of rootstock overgrowth at bud union was clearly observed in Trifoliate orange and in all its hybrids, but with variable intensity. The degree of stionic congeniality did not correlate with any industrial, vegetative or yield trait studied.

6. Yields of plants on Trifoliate orange were, on average, lower than Rangpur lime and were intermediate on Sunki mandarin. The greatest yield was observed in plants on the TxS hybrids. SxT hybrids induced, on average, yields equivalent to Rangpur lime.

7. Production efficiency values were low for plants on Sunki mandarin and on the SxC, SxA and CxS hybrids. They were high on Trifoliate orange, Rangpur lime and the TxS and SxT hybrids due to more favorable combinations of yield and vigor. Promising genotypes were observed for these traits in all hybrid groups.

8. The internal and external morphological traits of the fruits and seeds of several hybrids analyzed were shown to be generally intermediate to the parents, although wide variation was observed. It were not observed restrictions regarding the number of seeds or phenotypic uniformity in the descent from these hybrids that would preclude their use as rootstock.

9. In a preliminary assessment, the industrial quality of Valencia orange over nine promising hybrids was equivalent to that of Rangpur lime. Some potentially more productive and with greater productivity than Rangpur lime might also induce greater soluble solids contents.

10. Of the 534 hybrids studied, 394 were CTV tolerant, of which 173 (44%) induced accumulated yield greater than Trifoliate orange, 119 (30%) greater than Sunki mandarin, 75 (19%) greater than Rangpur lime, 76 (19%) presented higher productivity than Trifoliate orange, 149 (38%) higher than Sunki mandarin and 65 (16%) higher than Rangpur lime, 166 (42%) greater yield efficiency than Sunki mandarin, 81 (21%) greater than Rangpur lime and 54 (14%) were more efficient than Trifoliate orange.

11. Ninety (23%) of the 394 CTV tolerant hybrids were selected jointly by the criteria trunk gummosis and *Phytophthora* root rot resistance, accumulated yield in seven years, productivity and production efficiency of Valência orange grafted on them. Twelve TxS, 29 SxT, 23 SxC, 13 SxA, 7 CxA, 5 TxA and 1 CxS hybrids were incorporated in the Germplasm Collection of the Instituto Agronômico de Campinas for future research and trials as potential rootstocks.

ACKNOWLEDGMENTS

The authors thank Debir N. Gomes for conducting the field, Benedito Vanderlei da Cunha and Osvaldo Betti for the grafts, Valéria X. P. Garcia for the industrial analysis, Silvia Luisa S. Lima for typing and José Márcio da Cruz for the software MINITAB version 14.

REFERENCES

ANDERSON, C.M. A situação dos porta-enxertos na Argentina. In: Seminário Internacional de Citros, I., 1990, Bebedouro. Anais... Jaboticabal: FUNEP, 1990. p.23-28.

BALLVÉ, R.M.L.; BORDIGNON, R.; MEDINA FILHO, H. P.; SIQUEIRA, W.J.; TEÓFILO SOBRINHO, J.; POMPEU JúnioR., J. Isoenzimas na identificação precoce de híbridos e clones nucelares no melhoramento de citros. **Bragantia**, Campinas, v. 50, n. 1, p. 57-76, 1991.

BALLVÉ, R.M.L.; MEDINA FILHO, H.P.; BORDIGNON, R. Identification of reciprocal hybrids in citrus by the broadness of leaf petiole wing, **Brazilian Journal of Genetics**, Ribeirão Preto, v.20, n.4, p.697-702, 1997.

BALLVÉ, R.M.L.; MEDINA FILHO, H.P.; BORDIGNON, R.; LIMA, M.M.A. Methodology for starch gel electrophoresis and protocols for isozyme of 32 plant genera. **Brazilian Journal of Genetics**, Ribeirão Preto, v.18, n.3, p.441-502, 1995.

BONNS, W.W.; MERTZ, W.M. Experiments with stocks for citrus. **California Agriculture Experimental Station Bulletin**, Berkeley, v.267, p.275-301, 1916.

BLUMER, S.; POMPEU JUNIOR, J.; GARCIA, V.X.P. Características de qualidade dos frutos de laranjas de maturação tardia. **Laranja**, Cordeirópolis, v.24, n.2, p.423-431, 2003.

BORDIGNON, R. **Hibridações interespecíficas, intergenéricas, intergrupais, intersubtribais e intersubfamiliares de Citrus e gêneros relacionados**. Campinas, 1995. 104f. Tese (Mestrado em Genética) - Instituto de Biologia, Universidade Estadual de Campinas.

BORDIGNON, R. **Características agronômicas e tolerância à tristeza de híbridos entre porta-enxertos elite de citros**. Campinas, 2000. 164f. Tese (Doutorado em Genética e Biologia Molecular) - Instituto de Biologia, Universidade Estadual de Campinas.

BORDIGNON, R.; MEDINA FILHO, H.P.; BALLVÉ, R.M.L. Melhoramento genético de citros no Instituto Agronômico. **Laranja**, Cordeirópolis, v.11, p.167-176, 1990.

BORDIGNON, R.; MEDINA FILHO, H.P.; MÜLLER, G.W.; SIQUEIRA, W.J. A tristeza dos citros e suas implicações no melhoramento genético de porta-enxertos. **Bragantia**, Campinas v.62, n.3, p.345-355, 2003a.

BORDIGNON, R.; MEDINA FILHO, H.P.; SIQUEIRA, W.J.; PIO, R.M.. Efeito da tristeza em caracteres vegetativos, produtivos e industriais da laranjeira Valência enxertada em híbridos segregando para tolerância. **Bragantia**, Campinas, v.62, n.2, p.207-215, 2003b.

BORDIGNON, R.; MEDINA FILHO, H.P.; SIQUEIRA, W.J.; PIO, R.M. Características da laranjeira Valência sobre clones e híbridos de porta-enxertos tolerantes à tristeza. **Bragantia**, Campinas v.62, n.3, p.381-395, 2003c.

BORDIGNON, R.; MEDINA FILHO, H.P.; SIQUEIRA, W.J.; TEÓFILO SOBRINHO, J. The genetics of tolerance to tristeza disease in citrus rootstock. **Genetics and Molecular Biology**, Ribeirão Preto, v.27, n.2, p.199-206, 2004.

CAMERON, J.W.; FROST, H.B. Genetics, breeding and nucellar embryony. In: Reuther, W; Batchelor, L.D.; Webber, H.J., (Ed.). **The Citrus Industry**. Berkeley: University of California Press, 1968. v.2, p.325-370.

CARLOS E.F. Avanços na pesquisa do declínio. **Informativo do Centro de Citricultura**, Cordeirópolis, 118, p.3, 2005.

CARVALHO, M.R.T.; BORDIGNON, R.; BALLVE, R.M.L.; PINTO-MAGLIO, C.A.F.; MEDINA FILHO, H.P. Aspectos biológicos do reduzido número de sementes da tangerina 'Sunki'. **Bragantia**, Campinas, v.56, n.1, p.69-77, 1997.

CASTLE, W.S. Citrus root systems: their structure, function, growth and relationship to tree performance. In: International Citrus Symposium, 1., 1978, Sidney. **Proceedings**... Riverside: International Society of Citriculture, 1978. v.1, p.62-69.

CASTLE, W.S. Citrus rootstocks. In: ROM, R. C.; CARLSON, R. F. (Ed.) **Rootstocks for Fruit Crops**. New York: J. Wiley and Sons, 1987, p.361-399.

CASTLE, W.S.; TUCKER, D.P.H.; KREZDORN, A.H.; YOUTSEY, C.O. Rootstocks selection: the first step to sucess. In: WOESTE, J. T. (Ed.). **Rootstocks for Florida citrus**. Gainesville: University of Florida, 1989. 47p.

CLEVELAND,W.S. Robust locally weighted and smoothing scatterplots. **Journal of the American Statistical Association**, Alexandria, v.74, p.829-836, 1979.

DE NEGRI, J.D.; BLASCO, E.E.A. Planejamento e implantação de um pomar cítrico In: RODRIGUEZ, O.; VIÉGAS, F.; POMPEU JUNIOR, J.; AMARO, A.A. (Ed.) **Citricultura Brasileira**. Campinas: Fundação Cargill, 1991. v.1, p.318-322.

DI GIORGI, F.; IDE, B.Y.; DIB, K.; MARCHI, R.J.; TRIBONI, H.R.; WAGNER, R.L. Contribuição ao estudo do comportamento de algumas variedades de citros e suas implicações agroindustriais. **Laranja**, Cordeirópolis, v.11, n.2, p.567-612, 1990.

DOMINGUES, E.T.; TEÓFILO SOBRINHO, J.; MATTOS JÚNIOR, D.; POMPEU JÚNIOR, J.; OLIVEIRA, L.A. Qualidade e maturação das laranjas Ovale, Ovale de Siracusa e Ovale San Lio. **Laranja**, Cordeirópolis, v.17, n.1, p.143-158, 1996.

DOMINGUES, E.T.; TULMANN NETO, A.; TEÓFILO SOBRINHO, J.; MATTOS JÚNIOR, D.; POMPEU JÚNIOR, J.; FIGUEIREDO, J.O. Seleção de variedades de laranja quanto à qualidade do fruto e período de maturação. **Laranja**, Cordeirópolis, v.24, n.2, p.471-490, 2003.

FERGUSON, L.; SAKOVICH, N.; ROOSE, M. **California Citrus Rootstocks**. Riverside: University of California, Division of Agriculture and Natural Resources, 1990. 18p. (Publication 21477)

HUTCHINSON, D.J. Rootstocks development: screening and selection for disease tolerance and horticulture characteristics. **Fruits Varieties Journal**, Blacksburg, v.39, n.3, p.21-25, 1985.

JESUS JUNIOR, W.C. BASSANEZI, R.B. Análise da dinâmica e estrutura de focos da morte súbita dos citros. **Fitopatologia Brasileira**, Brasília, v.29, n.4, p.399-405, 2004

MACHADO, M.A.; AMARO, A.A.; PINTO, W.B.S.; MIURA, M.; TOMAZELA, M.; MIRANDA, E.T. **Cadeia de produção de citros e a morte súbita:** análise e estratégias da Secretaria de Agricultura e Abastecimento do Governo de São Paulo. Governo do Estado de São Paulo. Fevereiro de 2003, 11p.

MEDINA FILHO, H.P.; BORDIGNON, R.; BALLVÉ, R.M.L.; SIQUEIRA, W.J. Genetic proof of the occurrence of mono and dizygotic twins in Citrus rootstocks. **Revista Brasileira de Genética**, Ribeirão Preto, v.16, n.3, p.703-711, 1993.

MEDINA FILHO, H.P.; BORDIGNON, R.; SIQUEIRA, W.J. Segregações gaméticas de locos isoenzímicos em porta-enxertos de citros e suas contribuições alélicas na formação de híbridos. **Bragantia**, Campinas v.62, n.3, p.357-367, 2003a.

MEDINA FILHO, H.P.; BORDIGNON, R.; SIQUEIRA, W.J.; FEICHTENBERGER, E.; CARVALHO, M.R.T. Tolerância de híbridos e de clones de porta-enxertos de citros à infecção de raízes por *Phytophthora nicotianae.* **Fitopatologia Brasileira**, Brasília, v.29, n.2, p.169-178, 2004.

MEDINA FILHO, H.P.; BORDIGNON, R.; SIQUEIRA, W.J.; FEICHTENBERGER, E.; CARVALHO, M.R.T.; TEÓFILO SOBRINHO, J. Resistência de clones e híbridos de porta-enxertos de citros à gomose de tronco causada por *Phytophthora parasitica.* **Fitopatologia Brasileira**, Brasília, v.28, n.5, p.534-540, 2003b.

MILLS, J.W. Citrus fruit culture. **California Agriculture Experimental Station Bulletin**, Berkeley, v. 138, p.1-46, 1902.

MÜLLER, I.A. Situação dos porta-enxertos no Uruguai. In: Seminário Internacional de Citros, 1., 1990, Bebedouro. **Anais...** Jaboticabal: FUNEP, 1990. p.29-41.

MÜLLER, G.W.;COSTA, A.S.; POMPEU JÚNIOR, J. Importância do porta-enxerto em relação à tristeza e outras moléstias dos citros no Brasil. In: Seminário Internacional de Citros, 1., 1990, Bebedouro. **Anais...** Jaboticabal: FUNEP, 1990. p.223-231.

MÜLLER, G.W.; DE NEGRI, J.D. AGUILAR-VILDOSO, C.A.; MATTOS JUNIOR, D. POMPEU JUNIOR, J.; TEÓFILO SOBRINHO, J.; CARVALHO, S.A.; GIROTTO, L.F.; MACHADO, M.A. Morte súbita dos citros: uma nova doença na citricultura brasileira. **Laranja**, Cordeirópolis, v.23, n.2, p.371-386, 2002.

ORTIZ, J.M. Porta-enxertos para citros na Espanha- presente e tendências futuras. In: Seminário Internacional de Citros, 1., 1990, Bebedouro. **Anais...** Jaboticabal: FUNEP, 1990. p.61-72.

OSAWA, I. Cytological and experimental studies in *Citrus*. **Journal of the College of Agriculture,** Tokyo, v.4, p.83–121, 1912.

PHILLIPS, R. L. Dwarfing rootstocks for citrus. In: International Citrus Symposium, 1., 1968, Riverside. **Proceedings...** Riverside: International Society of Citriculture, 1969. v.1, p.401-406.

POMPEU JÚNIOR, J. Situação do uso de porta-enxertos no Brasil. In: Seminário Internacional de Citros, 1., 1990, Bebedouro. **Anais...** Jaboticabal: FUNEP, 1990. p.1-10.

POMPEU JÚNIOR, J. Porta-enxertos. In: RODRIGUES, O.; VIEGAS, F.; POMPEU JÚNIOR, J.; AMARO, A.A. (Eds). **Citricultura Brasileira**, 2. ed. Campinas: Fundação Cargil, 1991. v.1, p.265-280.

POMPEU JUNIOR J.; FIGUEIREDO, J.O.; RODRIGUEZ, O.; ALUISI SOBRINHO, J.; SALIBE, A.A. Porta-enxertos para a laranja Valência, clone nucelar, em solo arenoso. In: Congresso Brasileiro de Fruticultura, 3., 1975, Seropédica. **Anais...** Jaboticabal: UNESP, 1975. p.371-379.

QUAGGIO, J.A.; MATTOS JÚNIOR, D.; CANTARELLA, H.; STUCHI, E.S. SEMPIONATO, O.R. Sweet orange trees grafted on selected rootstocks fertilized with nitrogen, phosphorus and potassium. **Pesquisa Agropecuária Brasileira**, Brasilia, v.39, n.1 p.55-60, 2004.

RICHARDSON, A.; MOONEY, P.; ANDERSON, P.; DAWSON, T.; WATSON, M. How do rootstocks affect canopy development? 1994 http://www.hortnet.co.nz/publications/science/r/richardson/rootcan.htm.

ROOSE, M.L. Porta-enxertos para citros na Califórnia. In: Seminário Internacional de Citros, 1., 1990, Bebedouro. **Anais...** Jaboticabal: FUNEP, 1990. p.51-60.

ROOSE, M.L.; COLE, D.A.; ATKIN, D.; KUPPER, R.S. Yield and tree size of four citrus cultivars on 21 rootstocks in California. **Journal of the American Society for Horticultural Science**, Alexandria, v.114, n.4, p.678-684, 1989.

RUSSO, F.; RECUPERO, G.R. Recent results of some citrus rootstocks experiments in Italy. In: INTERNATIONAL CITRUS CONGRESS, 6., 1984, São Paulo. **Proceedings...** São Paulo: International Society of Citriculture, 1984. v.1, p.42-45.

SALIBE, A.A.; MOREIRA, S. Performance of Rangpur lime as rootstock for citrus in Brazil. In: INTERNATIONAL CITRUS CONGRESS, 6., 1984, São Paulo. **Proceedings...** São Paulo: International Society of Citriculture, 1984. v.1, p.29-33.

SALIBE, A.A.; MISCHAN, M.M. Effect of ten rootstocks on tree size, early bearing and fruit quality of Satsuma mandarin trees. In: INTERNATIONAL CITRUS CONGRESS, 6., 1984, São Paulo. **Proceedings...** São Paulo: International Society of Citriculture, 1984. v.1, p.55-57.

SETIN, D.W.; CARVALHO, S.A. Recipientes e tipos de enxertia na produção de mudas de citros com porta-enxertos duplos. In: Mostra da Iniciação Científica e Pós - Graduação do Centro APTA Citros Sylvio Moreira - IAC, 1. 2005, Cordeirópolis. **Resumos...** CAPTACSM - IAC, Cordeirópolis, 2005. (CD-ROM).

SIVIERO, A. **Métodos de inoculação da Phytophthora parasitica e mapeamento de QTLs de resistência em híbridos de Citrus sunki vs Poncirus trifoliata à gomose**. 2001. 117f. Tese (Doutorado) – Faculdade de Ciências Agronômicas, Universidade Estadual Paulista, Botucatu.

SOARES, M.A. Aspectos importantes para se efetuar a colheita com qualidade. **Ciência e Prática**, Bebedouro, n.16, p.18, 2005.

SOOST, R.K.; CAMERON, J.W. *Citrus*. In: JANICK, J.; MOORE, J.N. (Ed.). **Advances in fruit breeding**. West Lafayette: Purdue University Press, 1975. p. 507-540.

STONECYPHER, R.W. Multiple-trait breeding. *Unasylva*, n.97-98, 1970. http://www.fao.org//docrep/a2173e/a2173e08.htm

STRASBURGER, E. Über polyembryonie. **Jenaische Zeitschrift für Naturwissenschaft**. Jena. v.12, p.647-667, 1878.

STUCHI, E.S.; DONADIO, L.C.; SEMPIONATO, O.R. Qualidade industrial e produção de frutos da laranjeira 'Valência' enxertada sobre sete porta-enxertos. **Laranja**, Cordeirópolis, v.23, n.2, p.453-471, 2002.

STUCHI, E.S.; SEMPIONATO, O.R.; SILVA, J.A.A. Influência dos porta-enxertos na qualidade dos frutos cítricos. **Laranja**, Cordeirópolis, v.17, n.1, p.159-178, 1996.

TEÓFILO SOBRINHO, J. **Comportamento da laranjeira Valência (Citrus sinensis L., Osbeck) sobre diferentes porta-enxertos**. 1972. 67f. Tese (Doutorado) – Escola Superior de Agronomia Luiz de Queiroz, Universidade de São Paulo, Piracicaba.

TEÓFILO SOBRINHO, J.; POMPEU JÚNIOR, J.; FIGUEIREDO, J.O.; BARBIN, D.; DEMÉTRIO, C.G.B. Fourteen-year study of rootstocks for 'Valência' and 'Natal' sweet oranges. In: INTERNATIONAL CITRUS CONGRESS, 6., 1984, São Paulo. **Proceedings...** São Paulo: International Society of Citriculture, 1984. v.1, p.27-28.

TEÓFILO SOBRINHO, J.; POMPEU JÚNIOR, J.; FIGUEIREDO, J.O.; MÜLLER, G.W.; LARANJEIRA, F.F.; DOMINGUES, E.T. Influência de onze porta-enxertos na produção e qualidade dos frutos da laranjeira Pêra, clone Bianchi. **Laranja**, Cordeirópolis, v.20, n.1, p.153-166, 1999.

TEÓFILO SOBRINHO, J.; SALIBE, A.A.; FIGUEIREDO, J.O.; SCHINOR, E.H. Adensamento de plantio para laranjeira 'Hamlin' sobre limoeiro 'Cravo' em Cordeirópolis (SP). **Laranja**, Cordeirópolis, v.23, n.2, p.439-452, 2002.

TOXOPEUS, H. Notes on the genetics of a few leaf characters in the genus *Citrus*. **Euphytica**, Dordrecht, v.11, n.1, p.19-25, 1962.

UPOV PRESS RELEASE nº 39, April 23, 1999. http://www.upov.org.

VENCOVSKY, R. Herança quantitativa. In: PATERNIANI, E. (Ed.). **Melhoramento e produção do milho no Brasil**. Campinas: Fundação Cargill, 1978. p.122-201.

VOLPE, C.A. Fenologia de citros. In: Seminário Internacional de Citros, 2., 1992, Bebedouro. **Anais...** Campinas: Fundação Cargil, 1992. p.107-120.

WEBBER, H.J. Complications in citrus hybridization caused by polyembryony. **Science**, Washington, v. 11, p. 308-309, 1900.

WEBBER, H.J. Variations in citrus seedling and their relation to rootstock selection. **Hilgardia**, Berkeley, v.7, n.1, p.1-79, 1932.

WEBBER, H.J. Rootstocks: their character and reactions. In: WEBBER, H.J.; BATCHERLOR, L.D. (Ed). **The Citrus Industry**. Berkeley: University of California Press, 1948. v.II, p.69-168.

WUTSCHER, H.K. Citrus rootstocks. In: JANICK, J. (Ed). **Horticultural Reviews**. Westport: AVI Publishing. 1979, p.237-269.

WUTSCHER, H.K. Porta-enxertos de citros na Flórida. In: Seminário Internacional de Citros, 1., 1990, Bebedouro. **Anais...** Jaboticabal, FUNEP, p.11-20, 1990.

WUTSCHER, H.K.; SHULL, A.V. Yield, fruit quality, growth and leaf nutrient leaves of 14-year-old grapefruit *Citrus paradisi*. Macf. trees on 21 rootstocks. **Journal of the American Society for Horticultural Science**, Alexandria. v.100, p. 290-294, 1975.

A **Série Ciência APTA** compreende os seguinte periódicos científicos:
Bragantia - Revista de Ciências Agronômicas, editado pelo Instituto Agronômico.
Arquivos do Instituto Biológico, editado pelo Instituto Biológico.
Agricultura em São Paulo, editado pelo Instituto de Economia Agrícola.
Boletim da Indústria Animal, editado pelo Instituto de Zootecnia.
Boletim do Instituto de Pesca, editado pelo Instituto de Pesca.
Revista de Tecnologia de Alimentos, editado pelo Instituto de Tecnologia de Alimentos.

A **Série Pesquisa APTA** corresponde a uma única série de boletins científicos para todos os Institutos de Pesquisa, numerados seqüencialmente, a qual se compõe de artigos e monografias de caráter científico, com mais de 30 páginas e periodicidade variável.

IAC
INSTITUTO AGRONÔMICO

apta
Agência Paulista de
Tecnologia dos
Agronegócios

SECRETARIA DE
AGRICULTURA E ABASTECIMENTO

GOVERNO DO ESTADO DE
SÃO PAULO
TRABALHANDO POR VOCÊ