

Thirty Years of Preimmunized Pera Sweet Orange in the Citriculture in São Paulo State, Brazil

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ABSTRACT. Brazil is the world largest citrus juice exporter and Pera sweet orange, a late season variety, is its main variety. In the late 1950's, many Pera orchards, already growing on citrus tristeza virus (CTV) tolerant rootstocks, were badly damaged by a CTV strain that caused stem pitting, small fruits, and stunted tree growth. In 1961, an extensive research project was begun to find mild isolates of CTV which could be used to cross protect citrus. Release of the best protecting Pera clone, #66, started 30 yr ago and was rapidly increased by growers. Since then, many experiments in São Paulo and other Brazilian states, showed that this Pera clone was superior to other clones. Large-scale propagation of this Pera clone has resulted in almost no breakdown in protection in successive clonal generations and presently, some 80 millions of trees descend from the original Pera clone. More recently, however, there have been a few cases where orchards with the protecting Pera clone have a great number of trees showing severe CTV symptoms. Studies are now underway to investigate the reasons for this breakdown and to find new mild isolates to protect Pera, mainly in the Southern part of São Paulo where the severe CTV strain known as the Capão Bonito complex occurs.

Index words. CTV, severe isolates, segregation.

Brazil is the world largest citrus juice exporter and its major variety is Pera sweet orange, a late season variety (4, 6). In the end of the 1950's, many of these orchards, already growing on tolerant rootstocks, were badly damaged by CTV, showing stem pitting, small fruits, and dwarfing (7). Growers claimed that Pera trees stopped growing or grew at a slower rate than trees of other varieties (19). The situation became so bad that it was advised to replace Pera with more tolerant varieties (16). However, because of its high fruit quality, Pera was preferred for both local and export fresh fruit markets, as well as for the newly developing processing industry. To continue to grow Pera, control measures had to be developed and cross protection was considered as the most promising option.

Previous work had established that mild CTV strains existed that had protective capacities (2, 5). Based on this, in 1961, a 5-yr cooperative research project was begun (funded by US Public Law 4-80) to find the best isolate to control CTV in commercial varieties, especially Pera, by cross protection.

The search for mild CTV isolates, field tests, and early results have been published previously (3, 9, 10, 12). Data based on tristeza and stem pitting readings, observations on plant growth, and yield from these trials, demonstrated that the best performing Pera trees were those pre-inoculated with a CTV isolate that had been collected on Sept. 12, 1962 from an outstanding Pera tree, existing at the São João farm, belonging to the Citrobrasil Co. and located in Limeira County, center of the São Paulo State. Indexed to Galego lime, it gave a mild CTV reaction.

It is interesting to note that on the day of this survey, the first author was with Drs. A. S. Costa, the "Father of Citrus Cross Protection in Brazil" and S. Moreira, the "Architect of the Citriculture of São Paulo". The collected budwood was designated #66 in the register of potentially mild CTV isolates, with a note indicating that it was the best tree so far observed.

Following are the steps that have happened since that time.

- In 1968, small scale distribution of Pera budwood from plants

inoculated with isolate #66 was begun.

- In 1974, the great majority of growers who had received this budwood responded in a questionnaire that these trees grew satisfactorily. There were approximately 1,000,000 trees at that time.
- In 1977 the cross-protected Pera ranked first in an experiment with several other Pera clones (18). Protection is maintained through successive clonal propagations (3). Occurrence of low percentage of bad plants was explained by CTV rootstock infection prior to budding with the Pera IAC isolate (3).
- By 1982, there were 20,000,000 protected Pera trees (13). In 1987, the number grew to 50,000,000 trees in São Paulo State.
- In 1990, the Pera IAC was one of the clones used to establish registered open field budwood increase nurseries by the São Paulo Government.
- In 1996, the good results of Pera IAC was reported to other Brazilian States (14, 15).
- In 1997, molecular biology studies indicate that the #66 isolate multiplies quicker in the tissues than the severe "Barão B" CTV isolate (17).
- In 1998, Pera IAC is the first Pera clone selected in the citrus certification program of São Paulo (1).
- In 1997, it was estimated that more than 80,000,000 protected Pera trees in nurseries, young as well as bearing orchards attested its high performance.
- In 1998, plants of STG Pera Bianchi clone are inoculated

with CTV isolate #66 (20), and are now performing extremely well in the south of the São Paulo State.

PROBLEMS AND THE FUTURE

The stem pitting control in Pera was satisfactorily achieved by using only the single mild CTV isolate labeled #66. This isolate afforded good protective effect and stability that holds now for nearly three decades. However, basing all protection of trees on only one mild isolate poses a risk of breakdown, as was observed more recently. There are some instances in which orchards propagated from the cross-protected Pera now have a greater than expected number of trees that are stunted, show stem pitting, and have uneconomic yields. Studies are now underway to investigate the reasons for this breakdown. Furthermore, the spread of citriculture to the Southwest region of São Paulo State, where the severe Capão Bonito CTV complex is prevalent (8), poses a problem to all sweet oranges and to the Rangpur lime rootstock. Also, in some instances, the cross-protected Pera have never done well (11). The above mentioned problems indicate that there is a need to identify new and better isolates for cross protection and that, besides protecting against the common severe isolates, new isolates must also be able to protect against the Capão Bonito CTV complex in Pera and other cultivars such as Natal, Valencia, and Hamlin. These cultivars form the bulk of the Brazilian citrus industry. Finally, there is a necessity to try to understand the mechanism of CTV cross protection.

LITERATURE CITED

1. Carvalho, S. A.
1998. Reestruturação do programa de registro de matrizes e revisão das normas para produção de mudas certificadas de citros no Estado de São Paulo. *Laranja* 19: 399-421.
2. Costa, A. S., T. J. Grant, and S. Moriera
1954. Behavior of various citrus rootstock-scion combinations following inoculation with mild and severe strains of tristeza virus. *Proc. State Fla. Hort. Soc.* 67: 26-30.

3. Costa, A. S. and G. W. Müller
1980. Tristeza control by cross protection. A U.S.-Brazil cooperative success. *Plant Dis.* 64: 538-541.
4. Donadio, L. C., J. O. Figueiredo, and R. M. Pio
1995. Laranja Pera. In: *Variedades Citricas Brasileiras, Jaboticabal*. FUNEP, 165-170.
5. Grant, T. J. and A. S. Costa
1951. A mild strain of the tristeza virus of citrus. *Phytopathology* 41: 114-122.
6. Hodgson, R. W.
1967. Horticultural varieties of citrus. Pera. In: *The Citrus Industry Vol I*. Walter Reuther (ed.), 449. University of California.
7. Moreira, S.
1960. Um novo problema nossa citricultura. *Rev. Agr. (Piracicaba)* 35: 77-82.
8. Müller, G. W., O. Rodriguez, and A. S. Costa
1968. A tristeza virus complex severe to sweet orange varieties. In: *Proc. 4th Conf. IOCV*, 64-71. Univ. Fla. Press, Gainesville.
9. Müller, G. W. and A. S. Costa
1968. Further evidence on protective interference in citrus tristeza. In: *Proc. 4th Conf. IOCV*, 71-82. Univ. Fla. Press, Gainesville.
10. Müller, G. W. and A. S. Costa
1977. Tristeza control in Brazil by preimmunization with mild strains. *Proc. Int. Soc. Citric.* 3: 868-872.
11. Müller, G. W., A. S. Costa, J. L. Castro, and N. Guirado
1988. Results from preimmunization tests to control the Capão Bonito strain of tristeza. In: *Proc. 10th Conf. IOCV*, 82-85. IOCV Riverside, CA.
12. Müller, G. W.
1980. Use of mild strains of citrus tristeza virus (CTV) to reestablish commercial production of Pera sweet orange in São Paulo, Brazil. *Proc. Fla. State Hort. Soc.* 93: 62-64.
13. Müller, G. W., A. S. Costa, and H. S. Prates
1982. Citrus tristeza control by preimmunization: a 10-yr review of its performance in Pera sweet orange commercial orchards. XXIst International Horticultural Congress, Hamburg, Federal Republic of Germany. Aug. 29 to Sept. 4, 1982.
14. Nakatani, A. K., J. H. M. Pinto, and R. P. Leite Jr.
1997. Avaliação de clones de laranja Pera em relação á tristeza dos citros na região norte do Estado do Paraná XXX Congr. Bras. De Fitopatol. 10-14 Agosto, Poços de Caldas, Mg. p. 340 (resumes).
15. Ogawa, T. and J. L. Mendonça
1996. Avaliação de clones de laranja 'Pera', em Anápolis. XIV Congr. Bras. Frut. p. 178 (resumos).
16. Rodriguez, O.
1961. "Tristeza" desaconselha a formação de novos pomares com laranja-Pêra. *Cooperotia*, marco de 1961. XVIII (137): 27-28.
17. Targon, M. L. P. N.
1997. Expressão e análise do gene do capsídeo de isolados do vírus da tristeza de diferentes espécies e variedades de citros. Tese de Doutorado. Unicamp. 142 pp.
18. Teófilo Sobr., J., J. Pompeu Jr., O. Rodriguez, J. O. Figueiredo, and D. Barbin
1977. Melhoramento de clones de laranja Pera no Estado de São Paulo. IV Congr. Bras. De Fruticultura, Cruz das Almas, BA.
19. Salibe, A. A.
1965. Stem pitting and decline of Pera sweet orange in the State of São Paulo. In: *Proc. 3rd Conf. IOCV*, 52-55. Univ. Fla. Press, Gainesville.
20. Salibe, A. A., O. J. Crocomo, A. Tubelis, L. A. Gallo, and E. T. de Oliveira
1993. A new program for citrus budwood improvement in São Paulo, Brazil. In: *Proc. 12th IOCV*, 392-396. IOCV, Riverside, CA.