Selection of Nucellar Pera Sweet Orange Clones with Regard to Tristeza Virus

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ABSTRACT. Two trials of Pera orange were reviewed and discussed to show the need to cross protect seedlings in an improvement program. Tree vigor, fruit quality and yield data were compared to stem pitting symptomatology of six nucellar clones. A straightforward relationship between the behavior of 14-yr-old trees and the severity of stem-pitting symptoms permits the clear conclusion about the inclusion of cross-protection as an important step in obtaining useful nucellar clones of Pera orange.

Index words. nucellar budline, late variety, virus disease.

Pera sweet orange is the citrus variety most widely grown in Brazil. The preference for this late variety, which ripens after July, is explained by the suitability of its fruits for internal and external marketing, and for processing. In some areas, such as the State of Bahia, Pera orange encompasses almost 100% of the citrus industry. Since the recognition of tristeza virus as a stem-pitting agent which causes serious damage to some intolerant varieties such as Pera (3, 4), research has shown the significance of this disease to an improvement program (1, 2, 5, 8).

The degree of tolerance for stem pitting, therefore, assumes great importance as far as an improvement program for Pera orange is concerned. A comparative study between nucellar and old clones of Pera orange carried out earlier in the State of Bahia showed that the nucellar trees were 60% more vigorous and 400% more productive than the old clone trees (6). This striking difference could be explained by the presence of psorosis in the old clone as well as its great susceptibility to stem pitting (7). Considering the importance of this variety for the Brazilian citrus industry, an improvement program was initiated in 1961 to obtain nucellar lines, productive and free from virus diseases.

MATERIAL AND METHODS

The trials were located at the Centro Nacional de Pesquisa de Mandioca e Fruticultura/EMBRAPA, Cruz das Almas, State of Bahia. Cruz das Almas is located at 12°40′39″ south latitude 39°06′23″ WGr longitude and at an altitude of 225 m in a hot, humid climate: the annual average temperature is 24C, rainfall is 1,197 mm and relative humidity 82%.

Trial 1. The test was planted in 1964, in a randomized block design with one tree per plot and 12 replications. The trees were grafted on Rangpur lime and the cultivars were as follows: A—a nucellar clone obtained by pollination with sour orange before 1960; B—a nucellar clone obtained from an open pollinated flower in 1961; C, D, E—nucellar clones obtained by pollination with sour orange in 1961; H—a nucellar clone from UEPAE/Itaguaí, Rio de Janeiro. Because no preinoculation was done, the trees were naturally infected with tristeza virus by *Toxoptera citricidus* Kirk, which is widespread in this area.

Trial 2. The test was planted in 1973 in a randomized block design with 3 trees per plot and 4 replications. The trees represented the best selections from the prior planting, which were A1, A6, C1, C9, C10, D3, D6, D9 and D12. Probably, these clones were naturally infected with a mild strain of CTV. A nucellar clone from the Citrus Department of Instituto Agronômico, Campinas, SP (naturally infected and designated as

TABLE 1
TREE CANOPY, HEIGHT AND CIRCUMFERENCE AND TRUNK DIAMETER OF NUCELLAR CLONES OF PERA ORANGE ONE YEAR AND 12 YEARS AFTER PLANTING (TRIAL 1)

Clone	Tree canopy				Trunk diameter (cm)	
	Height (m)		Circumference (m)			
	1965	1977	1965	1977	1965	1977
A	1.79bc[z]	3.59ab	3.80b	13.74bc	4.11b	16.59bc
B	1.98ab	3.88ab	4.04ab	14.84ab	4.70a	19.47a
C	1.99a	4.01a	4.44ab	15.24a	5.02a	18.99a
D	1.99a	3.85ab	4.67a	14.80ab	4.89a	18.45ab
E	1.87abc	3.96a	4.23ab	15.23a	4.75a	18.73a
H	1.77c	3.58b	2.92c	12.78c	3.79b	15.57c
CV	8.9	7.1	13.7	7.6	7.8	8.7

[z]Means within the same column followed by the same letter are not significantly different according to Tukey's test, P = 0.05.

P24) and a preinoculated clone (Pcp) from the Plant Pathology (Virus) Section of the same institution, were used as checks. Rangpur lime was also used as the rootstock. These trees were eradicated in 1984 due to toxicity caused by a copper sulfate mixture applied to the trunks.

In both trials, data were taken regarding tree growth—height, canopy and trunk diameter; yield and fruit quality—fruit height, weight and diameter and rind thickness; solids-to-acid ratio and seed number. The clones were not indexed. Measurements on stem-pitting symptomatology were made up to 1973, and in 1978. Five 25-cm- long branches were taken from around the canopy of each tree and were classified as very mild, mild, severe and very severe according to the severity of the symptoms.

RESULTS AND DISCUSSION

Tree vigor. Data on tree canopy, height and circumference, and trunk diameter taken in the period 1965-1977 are summarized in table 1. The B, C, D, and E clones showed the same performance, although the B clone was carrying a severe strain of stem pitting. In spite of the predominance of mild stem-pitting symptoms in the clone A, its vigor was poor. On

TABLE 2
YIELD OF PERA SWEET ORANGE IN RELATION TO THE DEGREE (%) TO STEM PITTING (TRIAL 1)

Clone	Average yield (tons/ha)			Stem pitting	
	1968/72	1973/77	1968/77	Up to 1973	1977
A	14.3	21.6	17.9	74% mild	92% mild 8% severe
B	11.1	17.3	14.3	100% severe	42% severe 58% very severe
C	14.0	19.8	16.9	42% mild	67% mild 25% severe 8% very severe
D	16.0	23.5	18.5	100% mild	84% mild 16% very mild
E	14.0	20.7	17.4	58% mild	92% mild 8% very mild
H	13.4	16.0	14.8	92% severe	64% mild 27% severe 9% very severe

the other hand, the clone B showed great vigor in the presence of severe stem pitting symptoms. This behavior suggests that the growth of the trees was related to their genetic condition. In trial 2, no significant differences were observed.

Yield and fruit quality. There was clear evidence of the influence of stem-pitting on yield potential of the trees. According to severity of the virus there was a high or low production per tree. The stronger the symptom, the lower the yield per tree, as shown in table 2. This fact emphasizes the need for preinoculation of Pera orange clones before their release. Since the clones D, C, and E had the same origin, the differences in susceptibility to stem-pitting are probably the result of a natural infection of the nucellar bud sources or of the rootstocks in the nursery with a mild cross-protecting strain. This fact was tested in a cross-protection trial where the D clone showed better performance even when inoculated with a severe strain. In trial 2, the first three years' data (table 3) showed some similarities among the treatments with the exception of the preinoculated clone planted one year later. However, as far as the peak of the production is concerned, this clone as well A1, C1, C9, C10, D6, D12 and E3 performed well, producing over than 39.3 tons/ha. Due to the performance of these clones, almost 2

TABLE 4
JUICE-CONTENT, WEIGHT AND BRIX: ACID RATIO OF NUCELLAR CLONES OF PERA ORANGE

Clone	Juice content (%)	Fruit wt. (g)	Brix: acid ratio
Trial 1, 1968-1977			
A	57.62 a[z]	216.3 ab	14.84 b
B	52.20 c	192.9 b	14.14 b
C	56.56 a	216.6 ab	16.43 ab
D	56.09 ab	230.3 a	16.01 ab
E	54.63 abc	221.2 a	17.99 a
H	52.86 c	209.4 ab	15.35 b
CV (%)	4	8	10
Trial 2, 1976-1981			
A1	56.9 bc	231.2 abc	14.30 abc
A6	57.7 abc	221.7 c	13.29 c
C1	58.2 abc	241.6 a	14.32 abc
C9	58.8 ab	241.7 a	14.41 abc
C10	58.2 abc	239.0 ab	15.07 ab
D3	58.5 abc	234.0 abc	14.38 abc
D6	58.4 abc	241.8 a	14.28 abc
D9	58.0 abc	231.3 abc	14.08 bc
D12	59.6 a	234.6 abc	13.83 bc
E3	58.2 abc	235.3 abc	15.21 ab
P24	56.4 c	226.7 bc	15.86 a
Pcp	56.9 bc	231.3 abc	14.91 abc
CV (%)	4	6	10

[z]Means within the same column followed by the same letter are not significantly different according to Tukey's test, P = 0.05.

TABLE 3
YIELD OF PERA ORANGE IN RELATION TO THE DEGREE (%) TO STEM PITTING (TRIAL 2)

Clone	Tree	Yield (tons/ha)[z]			Stem pitting (%) 1978[y]			
		1976/78	1979/82	1976/83	1	2	3	4
A	1	12.1	40.1	11.5	39	44	13	4
	6	11.1	36.4	12.2	24	53	20	3
C	1	13.5	49.5	18.0	35	51	9	5
	9	10.6	44.9	23.7	32	48	16	4
	10	10.2	51.9	20.8	45	47	7	1
D	3	11.6	38.6	12.9	60	28	12	—
	6	12.6	40.5	13.0	61	34	5	—
	9	10.7	38.7	14.5	48	44	6	—
	12	11.7	43.5	22.9	65	31	4	—
E	3	10.8	40.2	17.2	44	44	9	3
P 24	24	10.3	37.4	10.7	27	56	17	—
Pcp	—	7.8	39.6	14.8	65	32	1	1

[z]Yields in 1977, 1980 and 1983 were affected severely by droughts.
[y]1 = very mild, 2 = mild, 3 = severe, and 4 = very severe.

million buds were released for the citrus industry of Northeastern Brazil, mainly from clone D.

Table 3 shows the data related to juice content, fruit weight and solids-acid ratio in trial 1 from 1968 to 1977 and in trial 2 from 1976 to 1981. There were similarities among the C, D, and E clones that came from the same origin. However, the D clone had slightly less seeds per fruit, but fruit tended to be heavier than the others. The weight and juice content of the fruits tended to decrease in the clones with predominantly severe stem-pitting symptoms (clones B and H). Because the trees of trial 2 were the best selections of the first trial it was assumed that the fruit quality would be better. In fact, the fruits were juicier and heavier in trial 2 than in the first trial.

CONCLUSIONS

The data in this paper emphasized the importance of preinoculation in an improvement program of some intolerant varieties, such as Pera orange to stem pitting. The effect of stem pitting on behavior of Pera orange trees was evident, especially on yield of lines B and H. Samples were taken annually up to 1973 and again in 1978, and no striking differences were observed in the severity of the symptoms.

ACKNOWLEDGMENTS

We thank Dr. J. W. Cameron of the Department of Botany and Plant Sciences, University of California, Riverside, for assistance in editing this manuscript and R. C. Caldas of the EMBRAPA/CNPMF for statistical analyses of these data.

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