

# Performance of pummelo clones in the central mountain region of Puerto Rico<sup>1</sup>

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## ABSTRACT

Studies were conducted in the central mountainous region of Puerto Rico to determine the adaptability of 18 pummelo clones. Data on fruit number, weight and yield efficiency were collected during three consecutive crop years beginning the fourth year after planting. Clones Dry Pink, Thong Dee White and African Seedling were the best in terms of total number of fruits produced per tree. Production increased with age from over forty fruits for four-year-old trees to over sixty fruits per tree for six-year-old trees. Fruit weight per tree also increased with age, reaching a maximum of 87 kg of fruit for six-year-old trees. Clones Dry Pink and Thong Dee White were the best in terms of total fruit weight. Yield efficiency measured in terms of number of fruits per cm of stem diameter also increased with age from an average of 5.50 for four-year-old trees to 7.55 for six-year-old trees. Best yield efficiency was obtained with clones Dry Pink, Reinking, Thong Dee White and Green Favorite. These results indicate an excellent adaptability of the pummelo to the soil and climate conditions prevailing in the central mountainous region of Puerto Rico.

## RESUMEN

Comportamiento de clones de pomelo en la zona montañosa central de Puerto Rico

Se estudió la adaptabilidad de 18 clones de pomelo. Se tomaron datos sobre el número y el peso de las frutas y la eficiencia de rendimiento por 3 años en árboles que inicialmente tenían 4 años de establecidos. La producción de frutas por árbol fue superior en los clones Dry Pink, Thong Dee White y African Seedling. El número de frutas producidas por árbol aumentó con la edad, de más de 40 frutas en árboles de 4 años a más de 60 frutas en árboles de 6 años. El peso de las frutas por árbol también aumentó con la edad hasta un máximo de más de 87 kg en árboles de 6 años. Los clones Dry Pink y Thong Dee White fueron los mejores en término del peso de las frutas por árbol. La eficiencia en rendimiento determinada a base del número de frutas por centímetro de diámetro del tallo también aumentó con la edad de un promedio de 5.50 en árboles de 4 años a 7.55 en árboles de 6 años. La mejor eficiencia en rendimiento se obtuvo con los clones de Dry Pink, Reinking, Thong Dee White y Green Favorite. Estos resultados demuestran una excelente adaptabilidad del pomelo a las condiciones de suelo y clima prevalecientes en la zona montañosa del centro de Puerto Rico.

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### INTRODUCTION

The pummelo, *Citrus grandis* (L.) Osbeck, is a fruit of commercial importance in several countries of the Asian continent, including Thailand, Malaysia and Vietnam.<sup>5</sup> The date of its introduction to tropical America is uncertain, but it is supposed to have been introduced to the West Indies before its introduction to the United States in the early 1900s.<sup>6</sup> Although it grows well in the subtropics, the quality of fruits is better when grown in tropical environments.<sup>5</sup>

It is not known when the pummelo was first introduced to Puerto Rico, but before 1978 only the variety Tresca was known to exist on the island as a mature tree.<sup>5</sup> In the 1970s several pummelo introductions were made by the USDA-ARS Station in Mayagüez and planted there for preliminary evaluation. The most promising trees were selected for further propagation as clones and provided the propagation materials used in the present study. This study was conducted with the purpose of determining the adaptability and production potential of the pummelo in the central mountain region of Puerto Rico, where citrus fruits are an important crop.

### MATERIALS AND METHODS

Experiments were conducted at the Adjuntas Agricultural Substation in the central mountainous region of Puerto Rico. The climate in the area is characterized by a rainy season extending from August to November and a dry season from January to May, with an average annual precipitation of 1700 mm.<sup>7</sup> The soil type in the area is an Alonso clay, a light, friable, fertile soil belonging to the Orthoxic Tropohumults subgroup.

The plant material for the experiment consisted of 18 pummelo clones selected for superior yield and desirable fruit characteristics (table 1). Budwood of the clones was obtained from adult trees in a variety collection established at USDA-TARS, Mayagüez, P. R. Clones were budded to seedlings belonging to the African pummelo variety. These seedlings were germinated in sand and transplanted to 2-gal plastic bags filled with topsoil. Budded trees were kept in the plastic bags until they were planted in the field approximately one year later.

Trees were planted August 1980 at a distance of 6.4 x 7.6 m (20x25 feet). The experimental layout consisted of a partially balanced incomplete block arrangement with four replications. Seventy-two trees were planted to complete 18 blocks with four clones each and one tree per plot.

<sup>5</sup>Martin, F. W. and W. C. Cooper, 1977, Cultivation of neglected tropical fruits with promise. The Pummelo Publication. ARS-157.

<sup>6</sup>Chandler, W. H., 1964. The pummelo and grapefruit-Evergreen Orchards- Lea and Febiges-Philadelphia, Pa. Pages 153-69.

<sup>7</sup>Pérez, A. and C. J. Torres, 1984. Growth, yield efficiency and fruit quality of five navel orange clones during four years. *J. Agric. Univ. P. R.*- 68: 405-41.

TABLE 1.—*List of pummelo varieties indicating source and pulp color*

Variety	Source	Pulp color
Light Pink	Miami, Fla.	Pale green to cream yellow
Dry Pink	Miami, Fla.	Pale green to cream yellow
Thong Dee White	Texas	Cream-yellow
Wet Pink	Miami, Fla.	Pale Green to cream yellow
Red 16023	Texas	Light pink
Reinking	Indio, CA	Cream-yellow
Green Favorite	Miami, Fla.	Cream-yellow-green
Thong Dee 16024	Texas	Light Pink
Pink 9551	Miami, Fla.	Intense Pink
Siamese	Orlando, Fla.	Cream-yellow-green
African Seedling	Indio-CA	Light Pink
Tresca	Isabela, P.R.	Medium pink-green
Father Jerome	Florida	Yellow-green-pink
Pink 9552	Miami, Fla.	Cream-yellow-green
Chinese	Orlando, Fla.	Cream-yellow
Ogami	Orlando, Fla.	Medium pink
Isabela Hybrid	Isabela, P.R.	Medium pink
White 16026	Miami, Fla.	Cream-yellow

Trees were cultivated according to standard practices recommended by the Agricultural Experiment Station of the University of Puerto Rico.<sup>8</sup> No irrigation was provided and trees were hand-weeded when necessary.

From the fourth year after planting, data was collected on fruit production parameters such as number and size of fruits, internal and external color, juice content, seediness, appearance of central core, and on tree growth parameters such as trunk diameter, tree height and canopy width. Results here reported represent some of the data obtained from the three crops of 1984 to 1986.

#### RESULTS AND DISCUSSION

Table 2 shows data on average number of fruits per tree. There was little year to year fluctuation in production in most clones. This finding suggests the absence of biennial or alternate bearing in the pummelo. There was an increase in number of fruits per tree from 1984 to 1986. This increase can be attributed to young trees that continued to grow and enlarge the canopy during the 3-year period.

Cultivars Dry Pink, Thong Dee White and African seedling consistently produced more fruits per tree. Cultivars Wet Pink, Green Favorite, Thong Dee, Reinking, Pink 9252, Siamese and Father Jerome also produced well. Cultivars Pink 9551, Tresca, Ogami and Isabela Hybrid

<sup>8</sup>Estación Experimental Agrícola, 1987. Conjunto tecnológico para la producción de cítricas. Univ. P. R., Publ. 113.

TABLE 2.—Average number of fruits produced per tree in three consecutive crops

Variety	1984	1985	1986
Light Pink	21.30 abcd <sup>1</sup>	27.43 ab	32.80 abcde
Dry Pink	48.13 a	43.89 a	52.03 abc
Thong Dee White	37.37 ab	25.40 abc	66.21 a
Wet Pink	32.73 abc	29.70 ab	27.25 bcde
Red 16023	13.90 abcd	7.14 bc	29.08 bcde
Reinking	32.15 abc	34.24.ab	31.71 abcde
Green Favorite	31.33 abc	21.42 abc	18.84 bcde
Thong Dee	7.58 bcd	36.35 ab	41.98 abcd
Pink 9551	4.64 cd	16.01 bc	14.50 cde
Siamese	23.78 abcd	11.68 bc	34.99 abcde
African	28.22 abc	19.95 abc	52.34 ab
Tresca	0 cd	4.45 bc	0 e
Father Jerome	27.55 abcd	21.37 abc	15.89 bcde
Pink 9552	14.48 abcd	24.18 abc	27.60 bcde
Chinese	14.67 abcd	10.84 bc	18.29 bcde
Ogami	1.38 cd	8.47 bc	12.83 de
Isabela Hybrid	0 d	0.08 c	9.44 de
White 16026	32.74 abc	13.09 bc	31.50 abcde

<sup>1</sup>Means in columns followed by the same letter do not differ significantly at the 5% probability level.

produced the fewest fruits per tree. Maximum production was 48, 44 and 66 fruits per tree for 4-, 5-, and 6-year-old trees, respectively. Fruit count per tree is an important parameter since these large-sized fruits are usually sold on a fruit-unit basis.

Table 3 shows data on fruit weight. A pattern similar to that in fruit number was observed in weight of fruits per tree, which increased with age without marked year to year fluctuations. Cultivars Dry Pink, Thong Dee White, Wet Pink and Reinking were superior in terms of total average weight of fruit per year, with a significantly higher fruit weight during the 3 years. Fruits of cultivars Light Pink, Green Favorite, Thong Dee, African Seedling, Pink 9552 and White 16026 were bigger than those of cultivars Pink 9551, Tresca, Ogami and Isabela hybrid, which were the lowest in terms of fruit weight. Maximum yield obtained was 87.5 kg per tree for 6-year-old Dry Pink trees.

Table 4 shows yield efficiency calculated as number of fruit per cm of stem diameter. There were no marked differences in yield efficiency during the 3 years studied, probably because of the use of the same rootstock for grafting all the clones. There were no signs of incompatibility. The significant differences observed within years could have resulted from differences in canopy development in young trees. The average efficiencies observed, 5.50, 5.47 and 7.55 fruits per cm of stem diameter for trees 4, 5, and 6 years old, respectively, could serve as reference

TABLE 3.—Average fruit weight in kilograms per tree in three consecutive crops

Variety	1984	1985	1986
Light Pink	28.80 bcd <sup>1</sup>	38.50 abc	51.20 abc
Dry Pink	80.97 a	70.57 a	87.56 a
Thong Dee White	50.27 ab	32.43 abc	82.73 a
Wet Pink	48.03 abc	44.73 abc	40.05 abcd
Red 16023	17.75 bcd	6.90 c	35.68 abcd
Reinking	43.05 abc	48.32 ab	44.05 abc
Green Favorite	35.15 abcd	34.71 abc	34.89 bcd
Thong Dee	8.26 bcd	45.02 ab	52.71 abc
Pink 9551	6.88 cd	25.19 abc	22.70 bcd
Siamese	29.41 bcd	13.88 bc	39.62 abcd
African	37.52 abcd	24.81 abc	62.10 ab
Tresca	0 d	23.36 abc	0 d
Father Jerome	24.63 bcd	22.27 bc	9.90 cd
Pink 9552	24.14 bcd	37.50 abc	47.23 abc
Chinese	28.84 bcd	20.00 bc	34.24 bc
Ogami	5.78 cd	12.75 bc	23.98 bcd
Isabela Hybrid	3.76 cd	8.85 bc	30.26 bcd
White 16026	49.58 abc	16.18 bc	40.07 abcd

<sup>1</sup>Means in columns followed by the same letter do not differ significantly at the 5% probability level.

TABLE 4.—Yield efficiency as to number of fruits per cm of stem diameter in three consecutive crops

Variety	1984	1985	1986
Light Pink	5.16 abc <sup>1</sup>	6.34 abc	8.55 a
Dry Pink	11.96 a	10.45 a	13.21 a
Thong Dee White	8.40 ab	4.94 abc	12.75 a
Wet Pink	8.02 ab	7.76 abc	6.95 a
Red 16023	2.59 abc	1.15 c	6.43 ab
Reinking	7.78 ab	8.35 ab	7.74 a
Green Favorite	7.84 ab	8.13 ab	8.26 a
Thong Dee	1.73 bc	7.66 abc	9.24 a
Pink 9551	2.13 bc	5.10 abc	4.66 ab
Siamese	5.69 abc	3.19 abc	7.85 a
African	6.74 abc	4.44 abc	11.01 a
Tresca	0 c	5.48 abc	0 b
Father Jerome	6.79 ab	6.29 abc	4.05 ab
Pink 9552	4.72 abc	7.45 abc	10.27 a
Chinese	5.59 abc	3.57 abc	6.24 ab
Ogami	3.01 abc	2.96 bc	5.33 ab
Isabela Hybrid	2.14 bc	2.32 bc	6.63 ab
White 16026	8.70 ab	2.90 bc	6.76 ab
Average	5.50	5.47	7.55

<sup>1</sup>Means in columns followed by the same letter do not differ significantly at the 5% probability level.

value for future studies of this fruit since no comparable figures are available in the literature.

Table 5 shows cumulative data on total average number of fruits per tree, total average fruit weight and yield efficiency. Clones Dry Pink and Thong Dee White produced the most fruits during the 3-year period. Clones Reinking and African ranked next. On a fruit weight basis, Dry Pink and Thong Dee White were also superior. Cultivars Light Pink, Wet Pink, Reinking and African were also outstanding in terms of fruit weight.

Average yield efficiency figures in table 5 indicate performance on the basis of tree size. All varieties performed almost equally. The best ones were Dry Pink, Reinking, Thong Dee White, Green Favorite and Wet Pink. Only Tresca was statistically inferior.

Results demonstrate an excellent adaptability of the pummelo to the central mountainous citrus growing area of Puerto Rico. Growth and tree development was excellent in almost all clones, and except for gum exudate in some trees no signs of diseases were observed.

Many factors should be considered in selecting and recommending a particular pummelo cultivar because of the multiple uses the fruit may

TABLE 5.—Total average fruit number and weight, and average yield index in three consecutive crops

Variety	Total average production	Total average weight	Average yield index
		<i>kg</i>	
Light Pink	81.5 abc <sup>1</sup>	118.5 abc	6.53 abc
Dry Pink	144.0 a	239.0 a	11.83 a
Thong Dee White	128.9 a	165.4 ab	8.54 ab
Wet Pink	89.6 ab	132.8 abc	7.53 ab
Red 16023	50.1 bcd	60.3 acd	3.62 bc
Reinking	98.1 ab	135.4 abc	7.91 ab
Green Favorite	71.6 abcd	103.7 abcd	8.04 ab
Thong Dee	85.9 abc	106.0 abcd	6.20 abc
Pink 9551	35.1 bcd	52.9 cd	3.93 bc
Siamese	10.4 abcd	82.9 abcd	5.51 abc
African	100.5 ab	124.4 abc	7.34 ab
Tresca	0 d	0 d	0 c
Father Jerome	64.8 abcd	56.8 acd	5.71 abc
Pink 9552	66.3 abcd	108.8 abcd	7.43 ab
Chinese	43.7 bcd	83.1 abcd	5.11 bc
Ogami	22.6 cd	42.5 cd	3.72 bc
Isabela Hybrid	2.6 d	42.8 cd	3.68 bc
White 16026	77.3 abc	105.8 abcd	6.09 abc

<sup>1</sup>Means in columns followed by the same letter do not differ significantly at the 5% probability level.

have. In the present study only the parameters of fruit production, fruit weight and yield efficiency were considered. Results show that clones Dry Pink, Thong Dee White, African Seedling, Reinking and Wet Pink were superior, but production in almost all clones was excellent. Only clones Tresca, Ogami and Isabela Hybrid were consistently inferior in terms of the measured parameters.

Aspects of fruit quality, such as juice content, pulp color, pulp consistency, flavor, peel thickness, are also important for the final recommendation of a variety. A study of these parameters will be presented as a separate publication.