

'Pera' Sweet Orange

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'Pera' sweet orange [*Citrus sinensis* (L.) Osbeck], or 'Pera do Rio,' is the most widely planted citrus cultivar in Brazil, which is the largest-producing country of citrus fruits in the world. The Brazilian industry of frozen concentrated orange juice (FCOJ) accounts for 50% of world juice production and 80% of world exports, followed by the United States (exports 8%) and Mexico (3%) (23). The value of orange juice produced in Brazil and exported worldwide approaches \$ 1.1 billion annually.

The Brazilian orange juice industry has been based on the following four cultivars: 'Pera' (41% of orange trees), 'Natal' (26%), 'Valencia' (23%), and 'Hamlin' (3%) (1). The citrus growing area in the State of São Paulo (main citrus region in Brazil with approximately 85% of the trees) is about 770,000 ha or 200 million trees (10). There are more than 80 million trees (bearing and young trees) of 'Pera' producing nearly 160 million 40.8 kg boxes and occupying 310,000 ha, thus representing one of the largest production areas in the world.

It is estimated that 70% of oranges grown in Brazil are used for export in the form of juice, while the remaining 30% are sold as fresh fruit in the domestic market. However, in recent years there has been an increase in fresh fruit and juice consumption in Brazil, especially as freshly squeezed orange juice. For 'Pera,' this development is very important as this culti-

var represents 90% of the fresh, sweet oranges sold in Brazil (10).

The preference for 'Pera' in Brazil is due to the unique, sweet, and delicate flavor of the fresh fruit, appreciated by consumers, as well as its suitability as both a processing and fresh fruit commodity.

'Pera' is widely planted in Brazil, although it is not planted in other countries. Details of the origin of this cultivar are somewhat obscure. The words "do Rio" (in 'Pera do Rio,' as 'Pera' is also known in the domestic market) refer to the State of Rio de Janeiro, previously the main Brazilian production area in the early 1900's. However, it is not assumed that Rio de Janeiro is the area of origin of this cultivar. It is likely that 'Pera' originated in Florida in the USA, under the name of 'Lamb Summer,' a minor cultivar with no commercial importance (5, 22). According to Webber (1943), 'Lamb Summer' had been selected from seedlings grown in Volusia County, Florida, in the late 1800's by a nurseryman known as Mr. Lamb.

A sport of 'Pera,' named 'Perão,' has been identified in Brazil. This sport has large fruits (230-280 g) and is seedless.

The peak of anthesis of 'Pera' occurs between the months of August and September (spring in the Southern Hemisphere) with additional bloom periods in October/November, February/March, and May/June. All other major orange cultivars in Brazil have only one bloom period per year.

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Fruit is ovoid to ellipsoid in shape occasionally resembling a pear ("pêra" in Portuguese). The rind is smooth, shiny, yellow to red-orange with a greenish stem-end. There is a slight ring-shaped depression around the styler-end, a common symptom of plants infected by mild strains of citrus tristeza virus (CTV), and a circular indentation pattern around the pedicel insertion, which has thicker peel. The calyx remains attached to the harvested fruit.

The fruit has 10 to 11 carpels and contains few seeds (5 to 7 per fruit). Seeds are polyembryonic with one zygotic and several apomictic embryos (average of 1.6), developing from the nucellus thus producing true-to-type plants.

Although fruits ripen late (period from anthesis to maturation is about 12 months), mostly during the months of August to November, 'Pera' may occur year-round due to some off-season blossom. The major off-season production occurs mostly during the months of February to March due to a second bloom period during these months. At maturity, the fruit harvested during the off-season production cycle has uniform green color and a smooth rind in the State of São Paulo, as is the case with oranges grown in North and Northeast Brazil. Due to the several blossoms most fruits are inside the canopy. Fruit stores and ships well, which is due to the maturity season during the months of April to September (water-deficit period). The trees are not alternate bearers.

Fruits of 'Pera' average 52% juice content, 11.8% total soluble solids, 0.95% titratable acids, and a total soluble solids to titratable acids ratio of 12.5. Thus, these fruits show lower levels of total soluble solids and titratable acids than fruits of 'Valencia,' 'Natal,' and 'Hamlin,' but higher juice content and soluble solids to acids ratio (5, 18). In the coastal area of the State of Rio de Janeiro, where the temperature and relative humidity are higher than in the State of São Paulo, the fruits reach maximum quality in texture and higher ratio.

The juice of 'Pera' has been found to contain up to 350% higher concentration of total carotenoids (including β -carotene,

the most important source of vitamin A) than other orange varieties such as Valencia, Natal, Hamlin, Lima, and Baía (17, 25). In addition, the fruit has high concentration of other important health promoters such as the antioxidant compounds naringenin and hesperidin (11, 16).

'Pera' leaves are large, broad, and acuminate. Trees are evergreen with a dense and upright canopy. Although tree vigor is variable according to the rootstock used, soil, and the climate of the region, trees often attain heights of over 2.6 m. In general, trees are planted in a 6 x 5 m spacing, resulting in 330 trees per ha. However, this density is expected to increase up to 400 trees per ha in new plantings.

The main rootstock in commercial Brazilian groves is the Rangpur lime (*C. limonia* Osbeck). Scions budded on this rootstock are moderately vigorous and high yielding (8, 13, 20). Not rarely, yields of more than 60 t/ha are achieved when satisfactory fertilization is provided. In addition, this rootstock is tolerant to CTV (its most important characteristic for 'Pera') and has excellent drought resistance due to its deep and vigorous root system (3). This latter characteristic is extremely important in Brazil where irrigation is rarely used in orange groves. Scions propagated onto Rangpur lime produce medium-size fruit with moderate juice quality. However, this rootstock is susceptible to citrus slow decline nematode (*Tylenchulus semipene-trans*) and *declinio*, which has an unknown causal agent and expresses symptoms similar to citrus blight which has been reported in Florida, destroying millions of trees annually.

Some rootstocks are not recommended for 'Pera' orange due to their susceptibility to certain diseases or graft-incompatibility. 'Pera' is highly susceptible to CTV when grafted onto sour orange (*C. aurantium* L.) which had been the main rootstock in South America during the first-half of this century. Introduction of the CTV insect vector *Toxoptera citricidus* Kirk. had resulted in major losses of trees in 1940's and 1950's and promoted replanting with other tolerant rootstocks

such as Rangpur (14). Florida rough lemon (*C. jambhiri* Lush.), trifoliolate orange [*Poncirus trifoliata* (L.) Raf.], and its related rootstocks, such as Carrizo and Troyer citranges and Swingle citrumelo, are not recommended for use as rootstocks for 'Pera' due to their high level of graft-incompatibility (19). The tree is also highly susceptible to *Phytophthora* gummosis and drought when budded onto sweet orange (*C. sinensis*) (20).

The main diseases of 'Pera' are common to other sweet orange cultivars. However, 'Pera' is slightly damaged by severe strains of CTV even when budded on Rangpur lime, which led growers in São Paulo, in late 1950's, to replace 'Pera' for other late varieties such as Valencia and Natal. However, 'Pera' has continued to receive widespread acceptance due to the development of successful programs for registration and certification of preimmunized clones, i.e. infecting virus-free plants with a mild strain of the CTV which protects against attack by severe strains (4, 12, 15). The 'Clone Premunizado' or 'Pera-IAC' is the most commonly used clone and is the best fruit-bearing. Other clones include 'Olímpia,' 'Bianchi,' and 'Ipigúá.' These clones produce similar fruit and tree characteristics depending on the strain of CTV present. The main symptoms of CTV on 'Pera' include stem-pitting and longitudinal fissures (about four around the stem), small fruit, spoon- or boat-shaped leaves, zinc deficiency, die-back, and eventually death of the trees. Other viral diseases such as cachexia-xyloporosis, psorosis, and exocortis, are exclusively graft-transmissible and have been avoided by budwood certification programs (6, 7, 8, 21).

Currently, the main disease in Brazilian citrus groves is Citrus Variegated Chlorosis (CVC or *amarelinho*), a new citrus disease first detected during the late-1980's (2, 9). It is caused by a gram-negative xylem-limited bacterium (*Xylella fastidiosa*) which blocks sap transport, therefore, seriously affecting the growth and fruit production. Affected fruits remain small in size and develop a hard rind, while

leaves develop symptoms similar to Zn-deficiency. The disease and its vectors (species of sharpshooters) are widespread in Brazil, and are difficult to control.

The main physiological disorder of sweet oranges in Brazil, including 'Pera,' is granulation. Granulation is the occurrence of mature fruit with hard and tasteless juice vesicles, which are not edible. Granulation is associated with young trees grown in regions with extremely high temperatures, over-fertilization of trees with potassium (producing large fruit), deficient and unbalanced cations in the soil, and late harvest.

Although 'Pera' can be planted in a wide range of soils, generally trees are grown in regions of oxisols (common soil types in tropical countries), deep, with nearly flat overall topography, good drainage, and low fertility (highly deficient in phosphorus). The winter in the State of São Paulo is cool and dry, which results in fruits with good quality, especially the late varieties (6).

'Pera' fruit is not ideal for industrial juice extraction due to its oblong shape compared to the round shape of 'Valencia' orange. However, it is a traditional cultivar to growers and nurserymen as well as to consumers who enjoy its distinctive taste. This latter trait has encouraged its continued planting in new groves and resulted in its high price when sold in the fresh fruit market as compared to other cultivars. As a result, 'Pera' has been valuable for growers during low international juice prices, although the fresh fruit demands higher quality and thus increased production costs. Still, the citrus industry in Brazil has old familiar problems such as low yields (average of two boxes of 40.8 kg per tree) mostly due to the low levels of fertilization, inconsistent prices (because these change according to international trade market for FCOJ), and availability of only a few early to mid-season maturity orange cultivars for processing. Thus, it is expected that there will be a change in commercial cultivars grown; however it is expected also that 'Pera' will remain a popular and important cultivar in Brazil.

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M.9 Subclones and M.9 Crosses

With the group of M.9 selections there were no differences in tree growth, yield or average fruit size, except for Fleuren 56 which had lower yields and tree size. The highest yield was obtained on the more vigorous Jork 9. All 'Supporter' rootstocks decreased average fruit size of all cultivars. Yield and growth indices did not show any difference between the trees on 'Supporter' rootstocks in comparison with those on different M.9 subclones. Trees on Mark were the most vigorous in the trial. Yield of trees grown on P60 had more suckers and burrknots than any other rootstock. from Engel. 1999. *Apple Rootstock for Intensive Orchards*. *Proc. Int. Seminar Warsaw*. pp. 25-26.