The CNPFT/EMBRAPA Fruit Breeding Program in Brazil

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The National Research Center of Temperate Fruit Crops (CNPFT) (Fig. 1) is located at Pelotas, Rio Grande do Sul (RS), and is part of the Brazilian Agricultural Research Enterprise (EMBRAPA). The center has three experimental areas. The main unit, with 290 ha and 15,000 m² of construction, includes offices; laboratories of tissue culture, electrophoresis, plant breeding, entomology, plant pathology, immunology, plant nutrition, postharvest physiology, and food science; a library; and screenhouses. The second area (151 ha) is 10 km from the main unit and is used for the production of seeds and scions and for other activities related to the breeding programs. The third experimental area (114 ha) is located in Vacaria, in the mountain region of RS, the second most important area for apple production in Brazil. Experiments with apples (*Malus domestica* Borkh.), pears (*Pyrus communis* L.), plums (*Prunus domestica* L.), and collections of other fruit species are conducted in this unit.

HISTORY AND OBJECTIVES

The CNPFT was established 23 Jan. 1984 with the responsibility of coordinating the National Research Program of Temperate Fruits, which includes activities of other research institutions (e.g., state enterprises, universities) in eight states: RS, Santa Catarina, Paraná, São Paulo, Goiás, Minas Gerais, Espírito Santo, and Pernambuco. This program consists of > 100 research projects on diverse crops, 81 of them being developed by the CNPFT research staff.

The center also has a program (≈20 research projects) with regionally important vegetable crops, such as asparagus (*Asparagus officinalis* L.), carrots (*Daucus carota* L.), garlic (*Allium sativum* L.), onion (*Allium cepa* L.), potato (*Solanum tuberosum* L.), sweetpotato [*Ipomoea batatas* (L.) Lam.], and tomato (*Lycopersicon esculentum* Miller).

Among the temperate fruit crops, the center gives priority to studies with apple, blackberry (*Rubus* sp.), fig (*Ficus carica* L.), nectarine (*Prunus persica* var. *nucipersica* Borkh.), peach (*Prunus persica* L. Batsch), pear [*Pyrus communis* and *Pyrus pyrifolia* (Burn.) Nakai], plum (*Prunus salicina* Lindl.), prune (*Prunus domestica* L.), strawberry (*Fragaria ×ananassa* L. Duch.), and native fruit species, such as Brazilian guava (*Psidium cattleianum* Sab.), feijoa (*Feijoa sellowiana* Berg), and Brazilian cherry (*Eugenia uniflora* L.).

Collections of cultivars of blueberry (*Vaccinium ashei* Beade), cherry (*P. avium* L., *P. cerasus* L.), kiwi [*Actinidia deliciosa* (A. Chev.) C.F. Liang et A.R. Ferguson], pecan [*Carya illinoensis* (Wangenh.) K. Koch], and raspberry (*R. islaens* L.) are maintained and evaluated.

Before 1984, research in fruits and vegetable crops was conducted at the Experiment Station of Cascata, Ministry of Agriculture, which gave rise to the State Unity of Agricultural Research of Cascata (UEPAE de Cascata) that evolved to the present National Center.

Breeding programs, germplasm banks, research on biological control of diseases and pests, integrated pest and weed control, or-

chard management, electrophoresis, and postharvest physiology and storage of fruits are some of the priority areas of the CNPFT.

GERMPLASM BANKS

The center has two active germplasm banks: Prunoideas and asparagus. The bank of Prunoideas has >800 accessions, mainly *P. persica* and *P. salicina*.

The germplasm bank of asparagus has > 170 entries.

FRUIT BREEDING PROGRAM

The fruit breeding program at Pelotas began in the late 1950s with peach. At that time, peach was the most important fruit crop for the southern region of Brazil. By the 1970s, the apple industry had become so large and important that at present the majority of projects of the National Temperate Fruit Research Program are with apples.

Breeding programs for pear, plum, and small fruits, and recently the native species, are increasing in importance. Many cultivars have been released by the CNPFT (Table 1).

Peach

Brazil has ≈22,800 ha of peach orchards

Fig. 1. The National Research Center of Temperate Fruit Crops of The Brazilian Agricultural Research Enterprise (CNPFT/EMBRAPA).

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(IBGE, 1989), of which $\approx 12,000$ ha are located in RS.

In 1963 (Feliciano, 1979), when the breeding program officially began in Pelotas, only two cultivars were grown in RS: 'Aldrichi', a seed-propagated clingstone, and 'Delicioso', a white-flesh cultivar for fresh market. The peach harvesting period was ≈ 15 days long.

A few hundred clones were selected from seedling plants in the peach area of Pelotas, since the growers did not use asexual propagation at the time, and ≈ 200 cultivars and selections were introduced from Europe and the United States. Before then, in 1957, thousands of open-pollinated and hybrid seeds were collected in Florida, Georgia, North Carolina, Maryland, California, and particularly New Jersey (Feliciano, 1979).

At the beginning of the breeding program, top priorities were the expansion of the harvesting period, regional adaptation, fruit quality, and productivity. After the development and release of >40 peach cultivars, this program has provided the possibility of a peach harvest period of 100 days.

Today, the major goals are to obtain cultivars resistant to diseases, mainly to brown rot [*Monilinia fruticola* (Wint.) Honey] and bacterial spot [*Xanthomonas campestris* pv. *pruni* (Smith) Dye], to increase fruit size and improve flesh firmness and quality in general, and to provide fruits that can be transported to distant markets. Dual-purpose fruits, suitable either for fresh market or processing, are also desirable.

Some of the major problems that CNPFT research is addressing are related to mild winters and high humidity. In the southern region of Brazil, where peaches are grown, annual accumulated chilling hours range from 50 to 650 h. Areas with fewest chilling hours grow cultivars released by the Agronomic Institute of Campinas (IAC), São Paulo, with lower chilling requirements. In the states of RS, Santa Catarina, and Paraná, at least 90% of the commercial cultivars have been released by the Center in Pelotas, RS.

Spring frost is quite common in some areas as well as rain during bloom and ripening, which results in frequent frost damage and disease problems.

Some low-chilling genotypes have been identified that require a high heat accumulation for blooming, thereby escaping frost damage. Sources of disease resistance are being sought in the germplasm bank and also abroad to incorporate this character in commercial cultivars.

'Bolinha', a release of the CNPFT, and 'Kakamas', a South African cultivar, have some degree of horizontal resistance to brown rot. Local cultivars such as 'Convênio', 'Gaúcho', and 'Cristal Taquari' are being tested as sources of bacterial spot resistance due to their behavior in the field.

About 10,000 seedlings originating from controlled hybridizations are evaluated each year. Several selections of peach and nectarine are being evaluated in advanced tests for possible future release.

Apple

The apple industry in Brazil became commercially important by the 1970s. More than 28,000 ha are planted to apples, with 10,600 ha in RS alone (Agapomi, 1990). In the past 12 years, national production has increased from 14,000 to 392,000 t (Nakasu, 1990). The apple industry has stimulated economic development in a large area, creating thousands of jobs directly or in related areas, such as chemical industries, packinghouses, manufacture of fertilizers and machinery, etc.

The major objectives of the breeding program are the development of better-adapted cultivars, scab resistance [*Venturia inaequalis* (Cooke) Wint.], good quality, and desirably long storage life. The development of early ripening cultivars (before 'Gala') and those with fruits ripening with 'Golden Delicious', i.e., between 'Gala' and 'Fuji', and with bright red stripes are also among the major goals.

Two cultivars have been released by the CNPFT, both yellow-skinned apples, but now are obsolete. The first, 'BR-1', was released because of its productivity, size, adaptation, and, especially, earliness. However, the quality was not good. 'BR-2' produced good-quality apples, but the production was not consistently high and the local market prefers red apples.

From 20,000 to 30,000 seeds originating from controlled crosses are planted each year, and seedlings are submitted to a screening for scab resistance.

Pear

Until 1968, Brazil was one of the main pear producers in South America, averaging 55,000 t/year¹. Pear production has now decreased to $\approx 20,000$ t, due to susceptibility to diseases, lack of adapted cultivars, and use of an unsuitable rootstock. With the introduction of *P. calleryana* D-6 as rootstock and some European and Asiatic scion culti-

vars, the pear industry is expected to expand very soon (Nakasu and Leite, 1989).

In addition to breeding for new cultivars adapted to the conditions of southern Brazil and with resistance to scab (*V. pirina* Ad-erth.) and leaf spot (*Fabraea maculata* Atk.), the CNPFT provides cultivar recommendations to growers, based mainly on introductions observed in several collections, which are adapted to areas of 400 to 800 chilling hours.

For the mild winter areas, 'Carrick', 'Tenn', 'Barlett', 'Garber', 'Seleta', and the Asiatic-type pears such as 'Kosui', 'Ya-Li', 'Hosui', and 'Okusankichi' can be successfully cultivated. Some selections that originated from the breeding of the CNPFT-Pirus 1, 3, and 9—are also promising.

For the areas of higher chilling accumulation, 'Packham's Triumph', 'Africana', 'Highland', and the Asiatic types 'Século XX' and 'Hosui' are recommended, among others.

Plum

Plum culture in Brazil has been seriously threatened by leaf scald, a disease caused by rickettsia-like bacteria. In the last 5 years, clean material was released by CNPFT/RM-BRAPA, and the plum industry is being re-established.

In some areas of RS and Santa Catarina, bacterial spot [*Xanthomonas campestris* pv. *pruni* (Smith) Dye] is a limiting factor. Resistance to both bacterial and leaf scald are primary objectives in the program, in addition to quality and adaptation (Nakasu et al., 1981).

Compatibility among Japanese cultivars for satisfactory production has been studied under local conditions (de Carvalho and Raseira, 1992).

'Reubennel', 'Amarelinha', 'Rosa Mineira', 'Methley', 'Wade', 'Santa Rosa', 'Catari', 'Golden Japan', 'Pluma 7', and a

Fig. 2. A seedling of *Psidium cattleianum* Sab., showing the high productivity.

Table 1. Fruit cultivars released by the CNPFT/EMBRAPA.

Cultivar	Year released	Present status	Genealogy
<i>Peach, table cultivars</i>			
Alvorada ²	1969	Obsolete	Cardeal OP
Belvedere ²	1967	Limited commercial	(Delicioso x Interlúdio) OP
BR-1	1980	Commercial	Delicioso x Panamint
BR-3	1980	Commercial	Pala OP = (Coral x Paramint) OP
Chiripá	1975	Commercial	Delicioso x Nectared 5
Chimarrita	1987	Commercial	Babcock x Flordabella
Chula	1985	Limited commercial	Delicioso x Panamint
Coral ²	1966	Commercial	(Delicioso x Interlúdio) OP
Escarlata	1976	Limited commercial	Robusto x Panamint (Robusto = Delicioso x Taquari precoce)
Guadério	1976	Obsolete, breeding purposes	(Delicioso x Interlúdio) OP
Marli ²	1984	Commercial	Delicioso x Prelúdio
Pala ²	1978	Limited to colder regions	Coral x Panamint
Pálo	1978	Limited regions	Vespertino OP = (Admirável OP) OP
Piazito	1989	Home	Sunred x Dwarf Peach
Pilcha	1985	Limited commercial	(Precoce x Rosado) OP
Premier ²	1968	Commercial	Cardeal x 15 de Novembro
Princesa	1966	Obsolete	(Hawai x Southland OP) OP
Sentinelá	1985	Commercial	(Premier) OP
Sinuelo	1970	Commercial	Prelúdio x Amarelinho (Prelúdio seeds from New Jersey)
Sulina	1981	Limited commercial	Princesa x Premier
Vila Nova	1968	Commercial	Cristal x Princesa
Vila Velha	1968	Obsolete	Cristal x Princesa
Vinho ²	1966	Obsolete	(Delicioso x Interlúdio) OP
Xavante	1968	Obsolete	Prelúdio x Amarelinho (Delicioso x Admirável) OP
<i>Peach, processing type</i>			
Ágata ^y	1985	Limited commercial	(682011241 x C2R19T182) OP
BR-2	1980	Commercial	Aldrichi x Cerrito
BR-4	1980	Limited commercial	(Aldrichi x Cerrito) OP
BR-6	1980	Commercial	Ambrosio Perret x Tapes
Bolinha	1985	Limited commercial	(Aldrichi) OP probably
Capdeboscq	1966	Limited commercial	(Lake City x Intermediário) OP
Cerrito ²	1969	Limited commercial	(Lake City x Interlúdio) OP
Convênio ²	1966	Limited commercial	(Amsdem x Abóbora) OP
Diamante	1973	Commercial	Convênio x (Cardeal x Aldrichi) OP
Esmeralda	1987	Commercial	Alpes x RR 37201
Farrapos	1970	Limited commercial	(Edmundo Perret x Aldrichi) OP
Jade	1987	Limited commercial	(Alpes x RR 53272)
Madrugador	1970	Obsolete	(Aldrichi x Taquari precoce) OP
Magno	1977	Commercial	Ambrosio Perret x Tapes
Matutino	1970	Obsolete	(Aldrichi x Taquari precoce) OP
Morro Redondo ²	1967	Obsolete	(Lake City x Intermediário) OP
Ônix	1985	Limited commercial	Farrapos x Diamante
Precocinho	1981	Commercial	(Diamante) OP
Safira	1981	Limited	Ambrosio Perret x Cerrito
Tarumã ²	1970	Limited	Aldrichi x (Amsdem x Abóbora)
Topázio	1971	Obsolete	[Convênio x (Aldrichi x Taquari precoce)] OP
Turquesa	1982	Limited commercial	(Convênio x Cerrito) OP
Vanguarda	1989	Limited commercial	(Alpes x RR 53272) OP (Alpes = Aldrichi x Tapes)
<i>Dual-purpose peaches</i>			
Eldorado	1989	Commercial	Guadério x Serrano
Riograndense	1991	Commercial trial	(Brilhante x NJC 97) OP
<i>Nectarine</i>			
Branca	1989	V. limited	Goldmine x Pala
Bruna ²	1991	Limited commercial	NJ 238 x [(Candoka x Flaming Gold) x NJ N14] OP
Cascata ^y	1971	Limited to colder areas	(Sunhigh x Redcrest) OP
Linda	1989	Limited	(NJ 238 x Sunred) OP
Dulce	1991	Limited commercial	NJN 67 x Pala
Mara	1992	Limited commercial	Nectared 9 x Sunred
<i>Apple</i>			
Maçã BR-1	1979	Obsolete	Red Delicious OP
Maçã BR-2	1980	Breeding purposes	Golden Delicious OP
<i>Blackberry</i>			
Élbano ^w	1981	Commercial	[Comanche x (Thornfree x Brazos)] OP
Guarani	1988	Limited commercial	[Lawton x (Darrow x Brazos)] x (Shaffer Tree x Brazos)

continued

Table 1. Continued.

Cultivar	Year released	Present status	Genealogy
Tupi	1988	Limited commercial	Uruguai x Comanche
Negrita	1983	Limited commercial	Comanche x (Thornfree x Brazos)
Caingang	1991	Limited commercial	Cherokee x (Shaffer Tree x Brazos)
<i>Strawberry</i>			
Princesa	1958	Commercial	Cambridge OP
Konwoy-Cascata	1981	Commercial	Konwoy clone selection

*Originated from a joint program with the State Dept. of Agriculture-Estação Fitotécnica de Taquari.

*Seeds received from L.F. Hough, Rutgers Univ., New Brunswick, N.J.

*Joint release with IAPAR (Agronomic Institute of Paraná).

*Joint release with the Univ. of Arkansas, Fayetteville.

selection from the CNPFT Program, AM-4, are among the best for areas of 300 to 400 hours of chilling. In the mountain region, where >700 hours of chilling accumulate, 'Ozark Premier', 'Burbank', and the European types such as 'D'Agen', 'President', and 'Stanley' are recommended. Some of the cultivars listed above are susceptible to bacterial spot and are limited to small areas.

A screening procedure for bacterial spot is being studied. Besides the European cultivars, the Japanese type 'Bruce' and 'Burbank' are among the least susceptible.

Strawberry

The release of 'Princesa' and 'Konwoy-Cascata', for fresh market and processing, respectively, are the main contributions of the strawberry breeding program of the CNPFT. High productivity, disease resistance, uniform red fruit pigmentation, and firmness of the fruit flesh are some of the objectives being pursued.

Blackberry

The blackberry industry in Brazil is not large, but it is very promising. The center started a breeding program in the mid-1970s with the cooperation of J.N. Moore of the Univ. of Arkansas. The cultivars Ebano, Negrita, Tupi, and Guarani are results of this program. The U.S. cultivars Brazos, Comanche, Cherokee, and Cheyenne are also being grown successfully in the southern states of Brazil.

The major goal of the CNPFT blackberry breeding program is the development of cultivars that are adapted to local conditions, do not overlap in harvest with strawberries and peaches, and have erect, thornless canes producing firm, sweet fruits.

Native fruits

The native fruit species are being collected to preserve the germplasm. However, three species, all belonging to the Mirtaceae family, are the subject of more intensive work: *F. sellowiana*, *E. uniflora*, and *Psidium* sp. (possibly *P. cattleianum*) (Fig. 2). Seeds of selected clones of these species, found in woods, fields, or backyards, have been collected. Between 2000 and 4000 seedlings of each species are grown at the CNPFT and are being selected for fruit size, quality,

firmness, productivity, seed size, and high ratio between edible and nonedible portions.

Some selected clones have outstanding qualities, and propagation is being conducted for those. Parallel studies on pollen formation and viability are being conducted to provide information for use in future hybridizations. Cultural practices and propagation trials are also underway.

Other fruit species

The CNPFT maintains collections of quince (*Cydonia oblonga* Mill.), pecan, cherry, blueberry, fig, and kiwi fruit to observe the potential of those species in the region. The most promising ones will be studied further.

The researchers of the CNPFT are very interested in increasing the exchange of germplasm and information with other institutions that have programs with similar objectives.

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