A History and Description of the *Prunus persica* Plant Introduction Collection

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Peach is the second most widely planted temperate-zone tree fruit in the world, after apple. In contrast with apple, where a few major cultivars comprise a majority of commercial production, hundreds of peach cultivars are grown commercially worldwide. Most of these cultivars are closely related genetically, their origin tracing to 'J.H. Hale' or 'Elberta', and ultimately to 'Chinese Cling'. Many peach breeding programs in the United States have been largely based on 'Chinese Cling' germplasm since their inception. Remarkable advances have been made using this germplasm, and breeders can be proud of the fruit size and quality found in current peach cultivars. However, breeders worldwide realize that new sources of germplasm must be used in breeding efforts to meet the future needs of both the peach industry and consumers, and to develop new and novel cultivars that represent significant improvement over those currently available. One important source of germplasm for breeders in the United States is the U.S. Dept. of Agriculture (USDA) peach plant introduction (PI) collection.

Beginning in 1899 with PI 2679, the USDA imported from around the world >2100 clones or seed lots of peaches and nectarines as plant introductions. A collection of such introductions, once numbering ≈700 accessions, was housed at the USDA Plant Introduction Garden at Chico, Calif., until the late 1960s, and

consisted of clones that were introduced into the United States from China, the center of origin of peach, and from other parts of the world in the first part of the 20th century. Little use was made of this germplasm by most public and private breeders, who continued to focus on germplasm derived from 'Chinese Cling'. Exceptions included the use of germplasm to develop canning clingstone cultivars for California, the use of several clones for variety development by breeders at Rutgers Univ., and use by USDA and other breeders to develop rootstocks resistant to root-knot nematodes (*Meloidogyne* sp.). The collection was gradually reduced in numbers during the 1950s and 1960s, and eliminated with the closing of the Chico station in the late 1960s. As this was occurring, knowledge of virology and heightened concerns about introduction of injurious pests and diseases brought about stricter quarantine regulations, which dramatically reduced importation except for seed. W.H. Ackerman worked closely with the collection at Chico, and contributed much to our understanding of resistance to peach leaf curl [*Taphrina deformans* (Berk.) Tul.] and time of flowering (see literature cited). Unfortunately, most of the collection was lost with the closing of the station, with the exception of ≈60 accessions that were transferred to other USDA facilities, particularly Byron, Ga., and Beltsville, Md. A limited number of accessions also were retained at Rutgers Univ. The senior author obtained most of the extant peach introductions in 1982. They have been used in the breeding programs at both North Carolina State Univ. and the USDA Laboratory at Byron, Ga., and both authors have observed their

characteristics and performance over many years. In addition to their breeding value, these clones have unique traits not found in germplasm descended from 'Chinese Cling', and may be useful for fundamental genetic and physiological studies.

No single reference provides a thorough coverage of the history and characteristics of the accessions in the peach PI collection. Limited information on their history and characteristics is found in obscure government documents. A brief description of each new peach PI accession, as well as PI accessions of other species, was provided in plant inventory bulletins regularly published by the USDA [see U.S. Dept. of Agriculture (1924) for a representative citation of a plant inventory bulletin].

This manuscript describes the history and characteristics of the PIs introduced prior to the release of a new wave of imports in the 1980s as a result of an improved plant quarantine process. Information presented here is based on previously published information, together with the authors' observations. The common and scientific name, and the taxonomic authority for all diseases, mites, and nematodes referred to in the text are given in Table 1.

The history and dates of PI introduction were obtained from original government plant inventory documents (USDA, 1924). Information on susceptibility to fungal gummosis [*Botryosphaeria dothidea* (Moug. ex Fr.) Ces & de Not. = *B. ribes* Gross and Dugg.] was obtained from studies by Okie and Reilly (1983). Information on peach leaf curl resistance and spur-type growth habit was obtained

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Table 1. Common name, scientific name, and taxonomic authority of the disease, spider mite, and nematode species referred to.

Common name	Scientific name
Diseases	
Bacterial spot	<i>Xanthomonas arboricola</i> pv. <i>pruni</i> (Smith, 1903) Vauterin, Hoete, Kersters & Swings 1995
Brown rot	<i>Monilinia fructicola</i> (Wint.) Honey
Cytospora canker	<i>Leucostoma persoonii</i> Fr. (Nits.) Hohn. <i>Leucostoma cincta</i> (Pers. ex Fr.) Hohn.
Fungal gummosis	<i>Botryosphaeria dothidea</i> (Moug. ex Fr.) Ces & de Not. = <i>B. ribes</i> Gross and Dugg.
Leaf curl	<i>Taphrina deformans</i> (Berk.) Tul.
Oak root rot	<i>Armillaria tabescens</i> (Scop.) Dennis, Orton, and Hora
Mites	
Twospotted spider mite	<i>Tetranychus urticae</i> (Acari: Tetranychidae)
Nematodes	
Southern root-knot nematode	<i>Meloidogyne incognita</i> (Kofoid and White) Chitwood
Javanese root-knot nematode	<i>Meloidogyne javanica</i> (Treub) Chitwood
Root-lesion nematode	<i>Pratylenchus vulnus</i> (Allen and Jensen)
Ring nematode	<i>Criconebella xenoplex</i> {[<i>Mesocriconebella xenoplex</i>] (Raski) Loof and DeGrise}

from studies by Scorza (1992 and 1987, respectively). Response of some of the peach PIs to twospotted spider mites [*Tetranychus urticae* (Acari: Tetranychidae)] was described by Meagher and Werner (1992). Shi and Byrne (1995) characterized the tolerance of some of the peach PI accessions to iron chlorosis. In both of these studies, no superior accessions were identified, so no specific information is presented in this manuscript. Data on bacterial spot [*Xanthomonas arboricola* pv. *pruni* (Smith 1903) Vauterin, Hoete, Kersters & Swings 1995] resistance was obtained from field screening of the collection at the Sandhills Research Station, Jackson Springs, N.C. (Table 2). Estimates of chilling requirements (Table 2) were made by observing the flowering date of the PIs relative to that of numerous standard cultivars representing a wide range of chilling requirements. Information presented in this manuscript on isozyme genotypes was obtained from studies done by Mowrey et al. (1990) (Table 2).

Seedlings of many PI accessions, along with many commercial cultivars, were tested for root-knot nematode (*Meloidogyne* sp.) resistance during the 1930s and 1940s. Several PIs were highly resistant or immune (Day and Tufts, 1944; Long and Whitehouse, 1943; Weinberger et al., 1943), but no resistance was found in commercial germplasm. Although no reference was made regarding the nematode species used, later work showed that the two most resistant lines, PI 55776 ('Yunnan') and PI 63850 ('Shalil'), were resistant to southern root-knot nematode, *Meloidogyne incognita* (Kofoed and White), but not to Javanese root-knot nematode, *M. javanica* (Trueb) Chitwood (Lownsbery et al., 1959).

Much of the collection has been screened both in the greenhouse (Westcott et al., 1994) and field (Okie et al., 1994) for resistance to ring nematode, *Criconebella xenoplex* [*Mesocriconebella xenoplex*] (Raski) Loof and DeGrise and the associated Peach Tree Short Life (PTSL) syndrome. In the greenhouse, PI 65977 and PI 77876, among others, were slightly more resistant to ring nematode than the other 400 accessions tested, but all were good hosts. Okie et al. (1994) reported on the field longevity of numerous accessions of *Prunus*, including PI accessions. In long-term field trials, PI 134151 survived as well as 'Lovell', the commercial standard, but no PI was superior to 'Lovell', and some, including PIs 36126, 55776, 102705, 105362, 106062, 131209, and 151158, were much inferior. In this field trial, there were also apparent differences in mortality caused by oak root rot incited by *Armillaria tabescens* (Scop.) Dennis, Orton, and Hora (Okie et al., 1994; Okie et al., 1992), although the results were confounded by PTSL mortality. Root rot seemed less severe on PIs 55776, 43289, 65974, and 78544. In a subsequent PTSL trial (Beckman et al., 1994) using a range of 50 scions, including nine PIs, on a susceptible rootstock, PI 134151 showed survival superior to that of PIs 119839, 119844, 102705, 55836, or 62602.

In this manuscript, the term "quality" is used in a general sense to convey the overall

eating attributes of the fruit, including, but not confined to, sugar and acid content, flesh and skin bitterness, flesh texture, and other organoleptic properties. Small fruit are those <57 mm (2-1/4 inches) in diameter, medium fruit those from 57 to 70 mm (2-3/4 inches), large fruit those from 70 to 76 mm (3 inches) in diameter, and very large those >76 mm in diameter. Comments on external fruit color are based on a subjective appraisal of the attractiveness of the red blush and the ground color on the fruit surface. Fruit with a bright blush and ground color are rated good to excellent, while fruit with a dull red color and/or a green ground color at maturity are rated poor to fair. Plant introductions producing fruit that are described as "physiologically clingstone" are those that are genetically freestone, but ripen so early that separation of the flesh from the pit is incomplete, hence the fruit behave as if they were clingstone.

Little is known of the virus status of most of the clones in the peach PI collection, and some of the characteristics described in this manuscript may be a consequence of, or influenced by, virus infections. We have recently learned that some of the clones in this collection are infected with Asian Prunus Virus.

Many species of *Prunus*, including peach and nectarine, produce bitter seed, due to the accumulation of cyanogenic glucosides. Most of the PIs described in this report were tested for seed bitterness. All clones tested had bitter seed, except for PIs 34685 ('Quetta') and 129678 ('Stanwick'), both nectarines. Most accessions also were tested for male fertility by carefully examining anthers for evidence of pollen production at full bloom. Most clones were male fertile, except for PIs 72094 ('Hseuh Tao'), 106062 ('Killiekrankie'), 112032 ('Saharanpur No. 1'), 125025 ('China Flat'), 146137, and 240928.

In the descriptions that follow, four fruit characteristics are listed in abbreviated form. Symbols used are: P/N (peach or nectarine); S/M/L/VL (small, medium, large, or very large fruit size); W/Y (white-fleshed or yellow-fleshed); NC/MC/F (nonmelting clingstone, melting clingstone, freestone). Thus, P, S, W, NC indicates a peach that is small, white-fleshed, and nonmelting clingstone. Information on chilling requirement, date of ripening, leaf glands, flower type, resistance to bacterial spot, and isozyme genotypes are summarized in Table 2.

DESCRIPTIONS OF PEACH PIs

PI 34685 ('Quetta'). Seeds of PI 18235 were introduced from Quetta, India, in 1906. Seeds were collected by Lt. L.W. Maxwell, 127th Baluchistan Light Infantry, at an elevation of 1830 m. PI 34685, named in 1912, was a selected seedling of PI 18235 (Ackerman, 1959). 'Quetta' was the leading commercial nectarine grown in California in 1951 (Taylor, 1959). Fruit (N, S, W, MC) of 'Quetta' russets badly and is highly susceptible to brown rot. It is one of the two clones in the PI collection that have a sweet (nonbitter) seed (kernel). It was one of the two nectarine clones used in the

original crosses in early California nectarine breeding programs, is found in the pedigree of most commercial California nectarines, and is the source of the sweet kernel trait found in these fruits. This trait (*sk*) is inherited as a single recessive gene and is closely linked (12 cM) to the nectarine (*g*) gene (Creller and Werner, 1997). Fruit quality is fair. 'Quetta' is resistant to root-knot nematode, but poor germination of seed precludes its use as a rootstock (Day and Tufts, 1944).

PI 36126 ('Bolivian Cling'). Seeds from trees planted by the "Franciscan padres" in Bolivia were introduced by Edward M. Ehrhorn in 1913. Fruit (P, M, W, NC) is of fair quality and has pale yellow skin with little red color. Trees produce more spurs (Scorza, 1987) and are smaller than standard trees, and flower bud density is very high (Blake, 1933). This PI occurs in the pedigree of 'Babygold 6' peach, released by the New Jersey Agriculture Experiment Station in 1961.

PI 43289 ('Ying Tsui Tao', 'Eagle Beak'). PI 43289 was introduced from Guangzhou (formerly Canton), China, in 1916. Government records state that it was grown mostly in Guangdong Province at Sunchuen, in the Panyu district at Pontang, in the Nanhai district, and also in the Fayun, Sahshui, and Tungkun districts. Fruit (P, S, W, F) has green skin with little red overcolor, is heavily pubescent, and has a pronounced curved tip resembling the beak of an eagle, hence the common name. The flesh is very mild and sweet, with low acid. The pronounced tip and low acidity both are dominant in F₁ hybrids. Leaf size is small, and flower bud density is high (Okie and Werner, 1996). PI 43289 has moderate resistance to fungal gummosis (Okie and Reilly, 1983).

PI 55776 ('Yunnan'). Seeds of PI 55776 were collected from the wild by J.F. Rock, agricultural explorer of the USDA, in 1922 ≈13 km from the city of Puerhfu, Yunnan Province, China, at an altitude of 1525 m. The only survivor of a group of accessions from Yunnan Province, it is often referred to as 'Yunnan'. Fruit (P, S, Y, F) is very astringent, with little red color. The tree has high flower bud density (Blake, 1933), and is resistant to root-knot nematode, which is controlled by a dominant gene (Day and Tufts, 1944; Long and Whitehouse, 1943; Weinberger et al., 1943). Some seedlings are moderately resistant to *Pratylenchus vulnus* (Allen and Jensen), the root-lesion nematode (Day and Serr, 1951).

PI 55836 ('Amarillo Tardio'). Seeds of 'Amarillo Tardio' were received from southern Spain in 1916 as PI 43570. PI 55836 was a selected seedling from this lot. The round fruit (P, L, Y, NC) has little red overcolor and the quality is fair to good. The flesh tends to break down around the pit prior to ripening, particularly in hot weather. PI 55836 is potentially useful for development of late-flowering and late-ripening peaches.

PI 62602 ('Pi Tao'). Scions of this accession were collected near the Fa Hua Ssu temple near Haitzu, Chihli Province, China, in 1925 by P.H. Dorsett, USDA explorer, who stated that flowering twigs of this clone were sold on

Table 2. Summary of characteristics of the accessions in the *Prunus persica* plant introduction (PI) collection.

PI No.	CR ^z	Ripe date ^y	Leaf gland ^x	Flower type ^w	Bacterial spot ^v	Mdh ^u	Idh ⁱ	Cat ^s
34685	850	+25	R	Sh	47	B	A	A
36126	900	+34	R	Sh	30	B	C	B
43289	650	+10	R	Sh	45	A	C	A
55776	600	+32	R	Sh	57	B	C	C
55836	1000	+50		Sh	15			
62602	1000	+70	R	Dbl	18			
63850	650	+45	R	Sh	30	A	A	A
65821	400	+30	R	Dbl	47	E	C	C
65974	1000	+80	R	Sh	10	A	C	A
65977	1000	+40	R	Sh	10	B	A	A
72094	700	+01	R	Sh				
77876	1000	+60	R	Ns	50	D	B	A
78513	850	+22	G	Ns				
78544	850	+25	A	Sh	10	B	C	A
82413	750	+60	A	Sh	20	B	A	A
91459	1100	+65	R	Dbl				
93826	950	-10	A	Sh		B	A	A
95501	1000	+40	R	Sh	15	D	A	C
1016 (63)	1200	+55	R	Sh	50, 38,	D (63)	A	C
(67), (68), (86)					45, 50	A (67, 68, 86)		
101676	1000	+45	R	Sh				
101823	1000	+46	G	Ns	23	A	C	A
101835	1100	-25	G	Sh		B	A	A
102521	950		R	Ns				
102705	1100	+55	R	Sh	25	A	A	C
104287	1000	+60	R	Ns		B	A	
104488	800	+100	R	Ns	30	D	B	A
105362	1000	+25	A	Sh	10	B	C	A
106062	400	+15	R	Sh	43	F	C	B
112032	550	+40	R	Sh	13	E	C	A
112033	750	+40	R	Sh	30	B	B	C
113452	650	+50	R	Sh	58	D	C	
113455	900	+45	R	Sh	10	B	C	C
113650	500	+15	G	Sh	52	B	C	
117679	700	+55	R	Sh	57	D	C	
119836	900	+79	R	Ns				
119839	950	+47	R	Sh				
119840	700	+35	R	Ns	50	E	C	A
119842	750	+43	R	Sh				
119844	950	+25	R	Sh		B	C	A
119846	1000	+25	R	Sh	20	C	C	B
125017	750	+20	R	Sh	15	A	B	A
125025	300	+14	R	Sh	30	E	A	B
129674	550	+35	R	Sh	10	E	C	B
129678	950	+45	R	Sh	10	B	C	A
130980	650	+25	R	Sh	20	B	C	A
131034	650	-24	R	Sh	10	E	C	A
131075	1000	+25	R	Sh	10	B	C	A
131209	1000	+25	G	Sh		B	C	A
132007	650	+10	R	Sh	15	B	C	A
132739	700	+11	G	Sh				
132742	1000	+03	G	Sh				
132743	1000	+20	R	Sh				
133551	1000	+14	G	Sh	13	B	C	A
133741	700	+30	R	Sh	33	D	C	A
133982	1000	+80	R	Sh	10	B	C	A
133984	950	-07	R	Sh	15	B	C	A
133987	650	+55	A	Sh	25	B	C	A
134150	850	+55	R	Sh	16	B	C	A
134151	950	+70	R	Sh	17	B	A	A
134400	750	+65	R	Sh				
134401	950	+70	R	Sh	50	A	A	C
146137	950	+50	R	Sh	13	B	B	B
151158	1000	+21	A	Sh		B	C	C
240928	1200	+45	R	Sh	47	D	A	
324255	900	+44	G	Sh				
411149	950	+45	R	Sh				
414385	850	+14	R	Sh				
442378	650	+70	R	Sh	25	B	C	
442380	450	+60	R	Sh	50	B	C	A

^zChilling requirement (hours <7 °C).^yNo. of days clone ripens before (-) or after (+) 'Redhaven' peach.^xR = reniform, G = globose, A = absent.^wSh = showy, Ns = non-showy, Dbl = double.^vPercent leaf defoliation (0% to 100%), LSD = 23%. Each value is the mean for five single tree replications. Data taken 12 Aug. 1996 on 6-year-old trees at the Sandhills Research Station, Jackson Springs, N.C. Additional data on bacterial spot resistance of these introductions can be found in Werner et al. (1986).^uMalate dehydrogenase (Mdh) isozyme genotype. A = *Mdh* 1-3/*Mdh* 1-3; B = *Mdh* 1-2/*Mdh* 1-2; C = *Mdh* 1-1/*Mdh* 1-1; D = *Mdh* 1-2/*Mdh* 1-3; E = *Mdh* 1-2/*Mdh* 1-1; F = *Mdh* 1-1/*Mdh* 1-3. Data from Mowrey et al. (1990).ⁱIsocitrate dehydrogenase (Idh) isozyme genotype. A = *Idh* 1-3/*Idh* 1-3; B = *Idh* 1-2/*Idh* 1-2; C = *Idh* 1-2/*Idh* 1-2. Data from Mowrey et al. (1990).^sCatalase (Cat) isozyme genotype. A = *Cat* 1-2/*Cat* 1-2; B = *Cat* 1-1/*Cat* 1-2; C = *Cat* 1-1/*Cat* 1-1. Data from Werner (1992).

the streets of Haitzu. PI 62602 is beautiful in bloom, and the large, roselike double flowers emerge very late. Flower structure differs from that of common double-flowered peaches, in that the flowers have multiple pistils (mean of 3.4 per flower), and have ≈ 60 petals. In some inflorescences, more than one flower can be found, usually with one complete flower developed inside another. Fruit set is generally very low. Fruit (P, S, W, F) has little red blush, is unattractive, pointed, and of very poor quality. Susceptibility to leaf curl is high.

PI 63850 (seedling of 'Shalil'). Seeds of 'Shalil' peach, probably from a local seedling population, were collected from the Kurram Valley in the northwest provinces of India and introduced into the United States in 1913 as PI 36485. PI 63850 is a selected seedling of 'Shalil'. Fruit (P, S, Y, F) is round to slightly oval, heavily pubescent, has little red blush, and is of poor quality. It was one of the first peaches identified as resistant to root-knot nematode. (Day and Tufts, 1944; Long and Whitehouse, 1943; Weinberger et al., 1943).

PI 65821 ('Shau Thai Tao'). Seeds of 'Shau Thai Tao' were collected by F.A. McClure on the Canton Christian College farm in Guangdong, China, in 1925 and introduced in 1926. Flowers of the double-flowered clone (described as fragrant in the original documents), possess fewer petals than PI 62602, averaging ≈ 17 per flower. The fruit (P, S, W, F) is unattractive, has a pointed tip, and is of fair quality. Trees crop well for a peach with double flowers, and were probably grown for ornamental purposes in China. It is moderately resistant to fungal gummosis, and is resistant to root-knot nematode (Long and Whitehouse, 1944). It is an ancestor of the ornamental peach 'Flordahome' (Sharpe, 1960) and of 'Flordaguard' rootstock (Sherman et al., 1991), and possibly the source of resistance to the Florida strain of root-knot nematode that attacks 'Nemaguard' (Sherman et al., 1981).

PI 65974 ('De Coosa'). Introduced from Saonara, Padova, Italy, in 1926, plants of this PI were obtained from nurseryman Fratelli Sgaravatti. Fruit (N, M, W, F) is of fair quality, and the skin tends to crack and split on the suture, making it very susceptible to brown rot.

PI 65977 ('Gialla di Padova'). (Source as for PI 65974). The fruit (N, M, Y, F) has good quality. Unlike normal peaches and nectarines, the fruit skin and flesh of this clone produce no anthocyanin, and flowers are lighter pink. Carotenoids are produced in normal amounts, resulting in a fruit with bright yellow skin and deep yellow flesh with good texture. Studies by the authors suggest that the gene action controlling this trait is incomplete dominance; F_1 progeny show intermediate production of fruit anthocyanins. Chaparro et al. (1995) suggested that the mutation may be in an anthocyanin regulatory locus. This trait might possibly be used to facilitate the development of nectarines showing reduced levels of anthocyanin and a bright ground color. The tree flowers very late (Ackerman, 1957).

PI 72094 ('Hseuh Tao'). (Source as for PI 62602). Introduced in 1926, the name means

"bloody peach," apparently a reference to the "pink skin and red flesh." Our clone has white, nonmelting flesh, so the original clone may no longer exist. The fruit has a long point.

PI 77876 ('Tos China #1', 'Tos China Septembre'). PI 77876 was purchased from nurseryman Martino Bianchi of Pistoria, Tuscany, Italy, in 1928. It supposedly arose as a cross between a hardy, late Chinese peach and the Italian variety 'Teton de Venus'. The fruit (P, M, W, F) has greenish-white flesh with a modest red overcolor on the skin. Most seedlings are resistant to root-knot nematode (Long and Whitehouse, 1943).

PI 78513 ('Yennoh'). (P, L, W, F). PI 78513 was introduced as trees in 1929 from I.N. Riaboff, Government Botanical Garden, Nikita, Yalta, Crimea, Russia. It is resistant to *Cytospora* canker caused by *Leucostoma persoonii* Fr. (Nits.) Hohn. and *Leucostoma cincta* (Pers. ex Fr.) Hohn. (Chang et al., 1989). Seedling populations segregate 3:1 for an albino mutation.

PI 78544 ('Terzarola col Pizzo'). This accession was introduced as scions from Portici, Italy, by Professor Gaetano Briganti, Istituto Superiore Agrario. Fruit (P, M, Y, NC) has poor to fair quality.

PI 82413 ('Baladi #1'). Introduced as seed by A. Grasyovsky, subinspector of Agriculture and Forests, Jerusalem, in 1929, 'Baladi' is apparently a local seedling population. The fruit (P, S, W, F) is soft, with greenish skin and little red overcolor. It has high resistance to fungal gummosis.

PI 91459 ('Red Weeping'). This accession was received from Vistica Nurseries, Stockton, Calif., in 1931. The fruit (P, S, W, F) has poor color and quality. PI 91459 has the weeping growth habit (*pl* gene), attractive, double red flowers, is attractive in bloom, and flowers very late. In contrast with PI 62602, which has multiple pistils per flower, PI 91459 has only one pistil. It appears in the pedigree of 'Jerseypink' (Goffreda et al., 1992), and other ornamental peaches released by R.E.C. Layne at Harrow, Ont., Canada (Layne, 1981).

PI 93826 ('Inkoos'). Plants of this accession were purchased from H. Pickstone and Brothers Ltd., Simondium, Cape of Good Hope, South Africa, in July 1931. The fruits (P, L, W, MC) are of fair quality. Because of its very early ripening, the flesh adheres to the pit at maturity, but genetically it is freestone.

PI 95501 (no common name). Introduced as seed of a local, hardy peach in 1931 by Raymond Meyer, Oberlin Shansi Memorial Schools, Taiku, Shanxi, China, the fruit (P, M, W, F) is pointed and of poor quality. PI 95501 possesses some interesting characteristics that differentiate it from other peaches. Flower color is darker pink than wild-type peaches. A unique anthocyanin-expression mutation exists in this PI, and no anthocyanin is produced in stem tissue, except trace amounts near leaf scars (Chaparro et al., 1995), and fruit contain only trace amounts in the skin and flesh. Initial fruit set of PI 95501 is normal, but fruit drop is unusually high ≈ 70 –75 d after bloom; this seems to be related to high levels of embryo abortion, well after the onset of pit hardening.

PI 101663, PI 101667, PI 101668, and PI 101686 ('Feicheng Tao' or 'Ta Tao' #1, 5, 6, and 24, respectively). These accessions were introduced from China in 1933 as scions collected from the village of Shangchihtsun, west of Feicheng, Shandong, by Peter Liu of Peiping. All fruits in these accessions ripen ≈ 55 d after 'Redhaven'. These four plant introductions collectively share similar characteristics. All are unique in showing extremely late foliation and flowering in the spring, originally documented by Ackerman (1953, 1957). The physiological basis for this delayed bloom (chilling requirement vs. heat requirement) is unknown, but it occurs even when used as a rootstock or interstem (Okie, 1990; Reighard, 1992). Research by USDA indicates that these introductions are infected with Asian Prunus Virus (Hadidi and Levy, 1994), which appears to cause at least some of the delay in bloom when they are used as scions, rootstocks, or interstems. We have produced large F_2 populations by crossing PI 101668 with elite commercial cultivars and have been unsuccessful recovering F_2 progeny flowering as late as PI 101668, implicating the role of the virus in time of flowering and foliation in the parent PI. Leaves are considerably narrower than those of standard peaches, and branches grow in a more upright orientation. Few flower or vegetative buds are produced, resulting in many blind nodes (Okie and Werner, 1996). Fruit set is very poor in most years, whereas F_1 and F_2 progeny derived from crosses of 101668 with other commercial peaches set normally. Fruit (P, VL, W, NC) are up to 89 mm in diameter, and are very low in acid, but quality is only fair. Ovaries are extremely susceptible to freeze injury during flower development in the spring. All of these PIs are highly susceptible to fungal gummosis. A related accession, PI 101681 ('Ta Tao' #19), was used in the breeding program at Rutgers Univ., and is found in the pedigree of 'Jerseypink' (Goffreda et al., 1992).

PI 101676 ('Ku Chu's Hung' #14). (Source as for PI 101663, 101667, 101668, and 101686). The name of this accession means "millet season red peach." It is similar in characteristics to the Ta Tao series (see PI 101663), and sets poorly, commonly producing many "buttoned" fruit. Fruit (P, L, W, F) has greenish-white skin with little red overcolor, and is low in acid. It reportedly carries a dominant form of male sterility (Scott and Weinberger, 1944), but the data are suggestive of cytoplasmic male sterility.

PI 101823 ('Bienvenida'). Introduced in 1933 as plants from Morocco by H. Brayard, director of the Ferme Experimentale, Marrakech, the fruit (P, L, Y, NC) has fair to good quality. Flesh color is yellow to yellow-orange.

PI 101835 ('Precoced'Ampuis'). (Source as for PI 101823). The fruit (P, S, W, MC) is of poor quality. Although genetically a freestone, the flesh clings to the pit at maturity. The tree was rated by Ackerman (1953) as being immune to peach leaf curl, but showed light infection in the study by Scorza (1992).

PI 102521 ('Giallona di Papigno'). This

PI was introduced in 1933 as plants purchased from G. Giannini, Stabilimento d'Orticultura, Pistoia, Italy. Fruit (P, L, Y, NC) is large with little red blush, and is of poor quality.

PI 102705 (No. 501, Khodjent Kostokos). PI 102705 was introduced in 1933 as seeds from Khodjent Kostokos, USSR. Seeds, purchased through Dr. K. Pangelo, Bureau of Introduction, Institute of Plant Industry, Leningrad, were collected from trees growing between lat. 40° and 45°N in Turkestan and the Caucasian region. Seed were described as "striped," probably referring to the longitudinal ridges on the seed, a characteristic of *P. ferganensis*. Fruit (N, M, W, F) has little red overcolor, is of fair quality, and cracks readily. The tree is very late flowering.

PI 104287 ('Soleil d'Octobre'). (Source as for PI 102705). The fruit (P, M, W, F) has moderate red overcolor. The quality is fair to good for a very late ripening peach, and the accession is useful for breeding late-ripening peaches. The seedling progeny show a chlorotic leaf blotch (Okie and Reilly, 1989).

PI 104488 ('Gaschina Novembre'). Introduced as plants in 1934 from F. Ingegnoli, Milan, Italy, trees bear late-ripening fruit (P, L, W, F). This is the latest ripening PI in the entire collection. The quality is fair for the season, and the texture is less dry and mealy than most late peaches. The fruit has very little red overcolor on the skin. Seedling progeny show a chlorotic leaf blotch (Okie and Reilly, 1989).

PI 105362 ('Genovese'). Plants were introduced in Mar. 1934 from F. Sgaravatti, Saonara, Italy. The fruit (P, M, Y, NC) has little red overcolor. The attractive yellow-orange flesh has little anthocyanin and is of fair quality. The plant is highly resistant to leaf curl (Scorza, 1992).

PI 106062 ('Killiekrankie'). Plants purchased from H.E.V. Pickstone and Brothers, Simondium, Cape of Good Hope, South Africa, were introduced in 1934. The low acid fruit (P, S, W, F) is soft, has a pronounced tip, and is of poor quality. It is freestone, although records from Chico, Calif., describe it as a clingstone. It is probably heterozygous for a single recessive gene for male sterility, because offspring segregate for this trait.

PI 112032 ('Saharanpur No. 1'). Introduced in 1934 as plants purchased from the Government Botanical Garden, Saharanpur, India, this PI has round, soft fruit (P, S, W, NC) of poor eating quality with medium red overcolor on the skin.

PI 112033 ('Saharanpur No. 2'). (Source as for PI 112032). The soft fruit (P, S, W, NC) is of poor quality, with very bitter flesh. Fruit has little external color and contains a large pit. The tree is highly susceptible to fungal gummosis.

PI 113452 ('Rogani-Gow'). Introduced as plants in 1935 from the Institute of Plant Industry, Leningrad, USSR, this PI has pointed fruit (P, M, W, F) of poor quality with little blush on the skin. The small leaf and dry, cracking flesh suggested that it was a peach x almond hybrid, and this was confirmed by Byrne and Littlejohn (1988) through isozyme

analysis. Tree and flower size are smaller than standard. The tree has a high fruiting spur density (Scorza, 1987), probably inherited from its almond parent.

PI 113455 (Ferganensis #02446). (Source as for PI 113452). Based on parallel leaf venation and pit ridges, this clone is classified as a subspecies *P. persica* subspecies *ferganensis*. The round fruit (P, S, W, F) is of poor quality and has little red blush on the greenish-white skin.

PI 113650 ('Pollardi'). Introduced as plants in 1936 from Dr. M. Calvino, Stazione Sperimentale di Floricoltura, San Remo, Italy, isozyme analysis has shown this PI to be a peach x almond hybrid (Byrne and Littlejohn, 1988). The flesh type is almond-like. The tree was rated by Ackerman (1953) as being immune to peach leaf curl, but showed moderate infection in the study by Scorza (1992). The tree has high fruiting spur density (Scorza, 1987), probably inherited from its almond parent.

PI 117679 (No. 01370). Introduced in 1936 from N. Sharapov, Dept. of New Cultures, Institute of Plant Industry, Leningrad, USSR, isozyme analysis has confirmed this PI to be a peach x almond hybrid (Byrne and Littlejohn, 1988). The fruit (P, S, W, NC) is oblong with little external color and is of poor quality. The tree is small and has an upright growth habit. The flower is very small.

PI 119836 ('Khiditavsky', 'Khoditovsky', No. 224). (Source as for PI 117679; introduced in 1937). This clone was originally from Turkistan. The fruit (P, S, Y, F) is pointed, soft, and has little red blush on the skin.

PI 119839 ('Shirim Danak', No. 1281-T). (Source as for PI 117679). This clone was originally from Turkistan. The fruit (P, S, W, F) has no red color on the skin. It was reported by Hough and Bailey (personal communication) to have an edible kernel, but we have not verified this.

PI 119840 (No. 0195, 'Turnip Shaped'). (Source as for PI 117679). The fruit (P, L, Y, F) is pointed and of fair quality. The fruit pubescence is very dense, and the skin has a moderate red blush.

PI 119842 (Ferganensis No. 0439). (Source as for PI 117679). Leaf venation and pit markings in this PI are characteristic of subspecies *ferganensis*. The fruit (P, S, W, F) is of poor quality.

PI 119844 ('Krasvynos', No. 0932). (Source as for PI 117679). Purportedly a nectarine selected from seed gathered in the Ferghana Valley in Western Asiatic Russia, it was described on origin as a "flat red nectarine," and named 'Krasvynos' by M.A. Blake in 1944 (Blake, 1945). The parallel leaf venation suggests it is subspecies *ferganensis*. The fruit (N, M, W, F) has considerable attractive red overcolor on the skin. The fruit quality is poor with very bitter flesh. The tree flowers later than most commercial peaches, and it would be a useful source of genes for developing late-flowering varieties. PI 119844 is found in the pedigrees of 'Encore' (Frecon, 1981) and 'Summer Pearl' peaches, released by Rutgers Univ.

PI 119846 ('Platycarpa', No. 1383-T). (Source as for PI 117679). This clone was originally from Turkistan. The fruit (P, L, W, F) is flat (peento), and has good external color, but is soft and highly susceptible to brown rot. The flesh is low in acid, and has good quality. Because of its many desirable characteristics, this PI would be a good source of germplasm for breeding peento fruit, although it cracks badly, especially at the distal end.

PI 125017 ('Sary Oilor'). (Source as for PI 117679). This clone was originally from Turkistan. The round fruit (N, M, Y, F) has fair to good quality, but the external fruit color is only fair and shows a green ground color. The fruit show russetting and skin cracking in many years.

PI 125025 ('China Flat'). Introduced from India as plants collected in 1937 by W. Koelz, Bureau of Plant Industry, this PI produces low-acid, peento fruit (P, M, W, F) of poor quality. The fruit, which has a moderate red blush, is not as large as peento PI 119846. The distal end of the fruit cracks readily. The skin has a moderate red blush.

PI 129674 ('Angel'). (Source as for PI 106062, July 1938). This PI produces soft, fibrous fruit (P, M, W, F) of fair quality. Fruit have little red skin color.

PI 129678 ('Stanwick'). (Source as for PI 129674). 'Stanwick' is thought to be an old English cultivar allegedly grown from seed collected in Syria (Ackerman, 1959). The round fruit (N, M, W, F) has poor to fair quality, with astringent and fibrous flesh, and little red overcolor. The skin often cracks in wet weather. Like PI 34685 ('Quetta'), 'Stanwick' has a sweet kernel.

PI 130980 ('Proskauer'). Introduced as plants in 1938 from the Baumschule Wildsruff, Wildsruff, Germany, this PI apparently originated from seed obtained from Texas. The soft fruit (P, M, W, F) has a rough suture and pronounced tip, with dense pubescence and an attractive red blush. The fruit quality is fair. The tree is highly resistant to leaf curl (Scorza, 1992).

PI 131034 ('Spathe de Hallen'). Introduced as plants purchased from W. Kozminie, Poland, in 1938, this PI produces round fruit (P, M, W, F) with good quality and appearance for an early-ripening peach.

PI 131075 ('Violette Hative'). Although introduced as plants in 1938 from Clibrans Nursery, Ltd., Altringham, England, Ackerman (1959) noted that this clone does not fit the description of 'Violette Hative', an old French nectarine with white flesh. He suggested that it may actually be 'Rivers Orange' nectarine. Fruit (N, S, Y, F) is round with a dark red covering most of the surface, and has poor texture and quality. The tree tends to produce many "buttoned" fruit in some years.

PI 131209 ('Pineapple'). Introduced as plants in 1938 from J. Cheal and Sons, Ltd., Lowfield Nursery, Crowley, Sussex, England, 'Pineapple' is an old English cultivar originated by Thomas Rivers in 1870 (Ackerman, 1959). The fruit (N, M, Y, F) has a very attractive, deep yellow-orange flesh with a dark red skin color. The flesh quality is good

to excellent, but firmness is poor. The tree is very late flowering. 'Pineapple' would be a good source of germplasm for developing orange-fleshed peaches and nectarines, particularly late-flowering ones.

PI 132007 ('Rheingold'). Introduced as plants in 1939 from L. Spath, Berlin, Germany, this PI produces poorly colored fruit (P, S, W, F) with very light pubescence and a pronounced suture. The tree was rated by Ackerman (1953) as being immune to peach leaf curl, but Scorza (1992) rated it as highly resistant. In Scorza's study, it showed no symptoms of infection in two out of three years of observation, and only slight infection one year.

PI 132739 ('Erica Rudolf'). Introduced as plants in 1939 from Franz Bobeth, Meissen-Dobritz, Saxony, Germany, this PI produces soft fruit (P, M, W, F) with only a modest red blush on the skin.

PI 132742 (G.X.). (Source as for PI 132739). PI 132742 produces soft, poor-quality fruit (P, S, W, NC) with limited red skin color.

PI 132743 ('Luckenbusser I'). (Source as for PI 132739). PI 132743 produces soft, poor-quality fruit (P, S, W, F).

PI 133551 ('Peregrine'). Introduced as plants in 1939 from G. Nobelius and Sons, Gembrook Nursery, Emerald, Victoria, Australia, this PI produces good-quality fruit (P, M, W, F) with dense pubescence and attractive red blush.

PI 133741 ('Lady Palmerston'). Introduced in 1939 as plants from Balhannah Nurseries, Balhannah, South Australia, this PI was described by USDA-Chico as producing late-ripening fruit (P, L, Y, F). Our clone is a late-ripening yellow nectarine, suggesting that the original clone is no longer extant.

PI 133982 ('Herholdt's Late Cling'). Introduced in 1939 from J. Herholdt's and Sons, Johannesburg, Transvaal, South Africa, this PI produces good-quality fruit (P, L, Y, NC) with little external color. The tree produces "buttoned" fruit in many years.

PI 133984 ('Marina'). (Source as for PI 133982). The fruit (P, M, W, F) is very round with fair to good flesh quality, and an attractive red blush. PI 133984 is extremely susceptible to brown rot. It has unique fruit epidermal features, appearing intermediate between peach and nectarine. Creller and Werner (1996) have described the surface morphology of fruit of PI 133984 using SEM. Both the timing of initiation and the morphology of trichomes differ from those of standard peach. PI 133984 may be a periclinal chimera, because it arose as a bud sport from 'Duke of York' peach. Limited breeding studies suggest that the unique fruit surface phenotype of PI 133984 is not heritable. Further description of the surface characteristics of 'Marina' can be found in Creller and Werner (1996).

PI 133987 ('Nooiens Herholdt's Strain'). (Source as for PI 133982). The round fruit (P, Y, L, NC) have a slight tip and limited red skin color, restricted to the suture. The fruit pubescence is very dense.

PI 134150 (seedling of 'Bresquillo Durazos'). PI 134150 is a seedling selection made in 1939 at the USDA Plant Introduction

Garden in Chico, Calif., from PI 43569. PI 43569 was a seed lot of 'Bresquillo Durazos' obtained from Spain in 1916. The common name has little meaning. 'Bresquillo' is the name for peach in the Catalan language of Valencia, Spain, while 'Durazno' is the Spanish name for peach. The fruit (P, M, Y, NC) has attractive yellow-orange flesh with no red overcolor on the skin. Pubescence is dense, and fruit quality is poor.

PI 134151 (seedling of 'Transvaal Yellow Cling'). PI 134151 is a selection made in 1939 at the USDA Plant Introduction Garden in Chico, Calif., from a group of seedlings obtained from PI 87637. PI 87637 was a seed lot of 'Transvaal Yellow Cling' peaches obtained from N.B. Davis, Union Canning Co., Pretoria, South Africa, in 1930. The fruit (P, M, Y, NC) has bright yellow-orange flesh, with very little red overcolor on yellow skin. The quality is good for a late-ripening peach. The attractive flesh color and good fruit quality may make this clone useful in breeding late-ripening peaches. The tree is moderately resistant to fungal gummosis. Open-pollinated seedlings show a chlorotic leaf blotch (Okie and Reilly, 1989).

PI 134400 and 134401 (seedling of PI 80089). PI 134400 and PI 134401 are selections made in 1939 at the USDA Plant Introduction Garden in Chico, Calif., from a group of seedlings obtained as PI 80089. PI 80089 was introduced from China in May 1929 by Guy Walker of Laurel, Miss., who obtained it from the 'Imperial Peach Orchards'. Both clones produce very large (up to 90 mm in diameter), low-acid fruit (P, VL, W, F). The fruit is very sweet, and has no red overcolor when ripe. The suture is very pronounced. PI 134401 is very late flowering and sets poorly. Crosses between PI 134401 and commercial peach varieties showed that the large fruit size of the PI is transmitted to all F_1 progeny, suggesting a major dominant gene for fruit size. The pronounced suture and lack of skin color appears to be recessive; F_1 progeny show good color and normal suture characteristics. All F_1 progeny exhibit the low-acid character, suggesting that PI 134401 carries the dominant 'honey' gene. Leaves are longer and more narrow than those of standard peach. Tree growth is willowy and upright. The tree is highly susceptible to fungal gummosis.

PI 146137 (No. 142058, seedling of PI 105057). PI 146137 is a selection made in 1943 at the USDA Plant Introduction Garden at Chico, Calif., from a group of seedlings obtained as PI 105057. PI 105057 was a seedlot introduced in Apr. 1937 from the Institute of Plant Industry, Leningrad, USSR. Seeds originally were collected from trees growing in Faisabad, Tadjikistan. The fruit (P, M, W, F) is soft and pointed, with little red blush on the skin. Fruit quality is poor, with a bitter taste.

PI 151158 ('Jorge', 'Royal George'). PI 151158 was introduced as cuttings in 1945 from P. Yatman, Swift and Co., Buenos Aires, Argentina. The original 'Royal George' is an old English cultivar dating back to 1724, but it had white flesh and was freestone. This PI

produces unattractive fruit (P, L, Y, NC) with little red skin color and only fair flesh quality. The tree is moderately resistant to fungal gummosis and highly resistant to leaf curl (Scorza, 1992).

PI 240928 (seedling of PI 107838). PI 240928 is a selection made in June 1957 at the USDA Plant Introduction Station (by this date no longer referred to as a garden), Chico, Calif., from a group of seedlings obtained as PI 107838. PI 107838, called 'Mao Tao', was introduced into the United States in 1935 by Peter Lui, Peiping, China. Mr. Lui collected the seeds in the vicinity of Feicheng, where it was used as a rootstock (Ackerman, 1957). The low-acid fruit (P, S, W, F) has a pronounced tip and suture, and has very poor quality and appearance, with little red overcolor on the skin. The tree is very late flowering and male sterile. Male sterility in PI 240928 appears to be controlled by cytoplasmic factors, unlike other peach male steriles that are controlled by nuclear genes (Werner and Creller, 1997). This is the first confirmed cytoplasmic male sterile in a woody plant.

PI 324255 ('Golden Queen'). Introduced in 1967 as scions from Victorian Plant Research Institute, Burnley, Australia, this PI is a standard canning peach in Australia. The fruit (P, L, Y, NC) has yellow-orange flesh and little red overcolor on the skin.

PI 411149 (No. 745). Introduced in 1975 as cuttings from the Research Institute of Pomology, Skierniewice, Poland, PI 411149 was described as a nectarine in original documents, but the clone in U.S. collections is a peach with fruit (P, M, W, F) of good quality. The tree is late flowering.

PI 414385 ('Kiang-si', 'Paraguayos', 'Pavias Chinas'). Introduced as plants in 1977 from Arboricultura Frutal Viveros Orero, Segorbe, Spain, this PI produces low-acid, flat (peento) fruit (P, L, W, NC) that is unattractive and soft, with modest red blush on the skin.

PI 442378 (K792-056). Collected in 1979 by R. Knight and T. Whitaker, USDA, as seeds from fruit served in the restaurant of the Hotel Posado de Tampico, Tampico, Tamaulipas, Mexico. The local name of this peach was 'Durazno', which means peach in Spanish. The fruit (P, S, W, NC) has little red overcolor, is very firm, and has an almond-like flavor.

PI 442380 ('Evergreen', K792-296). The seeds of this PI were collected in 1979 at a public market in Tapachula, Chiapas, Mexico, by R. Knight and T. Whitaker. The local name again was 'Durazno'. The original four seedlings of this PI planted at Byron, Ga., appeared identical, and only one has been propagated and tested further. The fruit (P, S, W, NC) is firm and has an almond-like flavor, and has little red blush on the skin. This PI is often referred to as 'Evergreen'. Studies by Rodriguez et al. (1994) showed that evergreen types are "characterized by insensitivity of shoot tips to daylength and failure of terminal growth to cease until killed by low temperature." The authors suggested that "evergreen" may represent a phytochrome mutant. Lateral vegetative buds have an estimated chilling-hour requirement of ~400–500 h. 'Evergreen'

growth is controlled by a single recessive gene, *evg*, and gene action may be incompletely dominant, or alternatively, F_1 plants may have a lower chilling requirement and react differently from the nonevergreen parent. This clone may be useful for studying acclimation in woody plants because of its lack of a normal acclimation response in the fall (Arora et al., 1992). Mature trees at Byron, Ga., have withstood low temperatures of -16°C in 1983 and -21°C in 1988 without serious damage except to active terminal growth.

SUMMARY

This collection of germplasm represents a rich source of genetic diversity for peach breeders, given the many unique traits not found in descendants of 'Chinese Cling'. Although some accessions may have little or no breeding value, others could be useful as sources of disease resistance and other characteristics, as well as for more basic genetic and physiological studies.

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