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Stone Fruit Production and Breeding in Korea

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Abstract

Peach production in Korea dates back almost 2000 years. The current production area is about 10,000 hectares with annual yields of 127,500 metric tons. Kyongbuk province is the main area of production. Most peaches are white-fleshed and have low-acid flavor. Major varieties are 'Kurakatawase,' 'Okubo,' 'Yumyeong' and 'Hakuto.' Since controlled hybridizations of peach began in 1957, 3 peaches and a nectarine have been released by the National Horticultural Research Institute. In recent years breeding programs to improve plums and apricots have been started, but no varieties have been released, and the production areas for these crops remain limited.

Introduction

Korea is a peninsula located in Far Eastern Asia (Fig. 1) between 124°11' and 131°52' E longitudes and between 33°06' and 43°00' N latitudes. Because Korea lies in the temperate monsoon zone, winter is cold, spring and fall are warm and summer is hot and sultry. Climatic conditions in the main peach [*Prunus persica* (L.) Batsch] growing region are similar to Blacksburg, Va. More than 50% of annual precipitation is concentrated in the summer season. Under such climatic conditions, peach varieties originating from the southern China ecotype exhibit the best fruit qualities.

In the Korean fruit industry, peach (including nectarine) is the fifth most important deciduous fruit following apple (*Malus X domestica* Borkh.), grape (*Vitis vinifera* L.), pear (*Pyrus pyrifolia* (Burm.) Nak.), and persimmon (*Diospyros kaki* L.) (Tables 1, 2). Although plum (*Prunus salicina* Lindl.), apricot (*P. armeniaca* L. and var. *ansu* Max.) and mume (*P. mume* S. et Z.) are also grown, their cultivation areas and production are small compared to those of peaches (7). Stone fruits other than mume are usually consumed as fresh fruits. Korea also produces processed products such as canned peaches with the annual production about 17,000 M/T. However, bulk processed fruit is imported from both China and the Republic of South Africa for local canning because of the high price of domestically grown fruits.

Prunus Species

Prunus species that are native or naturalized in Korea are shown in Table 3 (6). Because naturalization occurred long ago, it is not possible to be sure which species are native. *Prunus persica* grows in a wild state all over the nation. *Prunus salicina* is also found in numerous mountainous areas in Korea. *Prunus salicina* var. *columnalis* Uyeki is an interesting form with a pillar type tree habit.

Peach Production

Although it is not clear when peach growing began in Korea, the literature on peach cultivation can be dated to the Silla era, A.D. 203. In the sixteenth century, or the Chosun era, six peach varieties were already known. However, the commercial peach growing era probably began with the introduction of white, melting, juicy varieties such as 'Shanghai Honey' and 'Tenjin Honey' by the Horticultural Experiment Farm, which was founded in 1906 in Seoul. Although the reason is not certain, most Korean people prefer peaches with flesh that is white, melting, juicy, sweet and low acid. These fruit characteristics are important criteria for the evaluation and selection of seedlings. Traditional peach varieties have been

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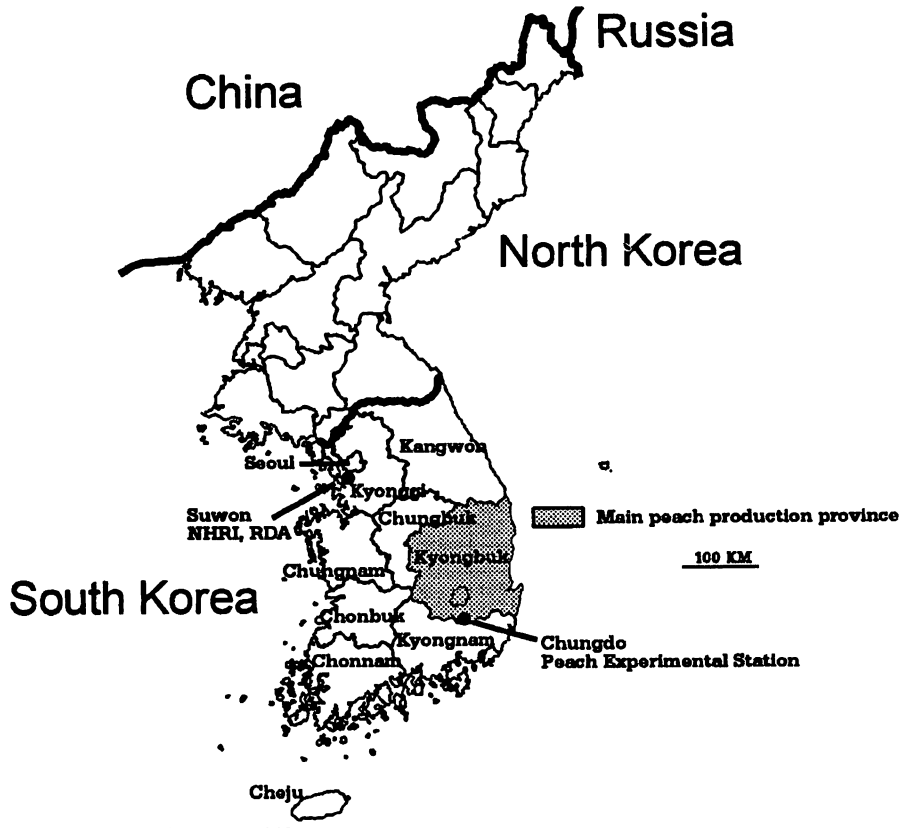

Figure 1. Provincial map of Korea.

rapidly replaced by the introduced peach varieties with better size and quality. Currently, such local varieties have nearly disappeared.

Peach cultivation has decreased steadily since 1986. This decreasing trend resulted from three factors: 1) removal of yellow flesh peach orchards in accordance with international trade agreements, 2) change in land utility and value due to the continuous enlargement of cities, and 3) aging of fruit growers. Recently, the area in production is increasing slightly due to high fruit prices during the past several years.

Four major peach varieties, 'Kurakatawase,' 'Okubo,' 'Yumyeong,' and 'Hakuto' occupy 67% of the total area in cultivation (Table 4). Excessive production of a particular variety sometimes causes drastic decreases in the price, which frustrates dissemination of new varieties that ripen at the same time as the four major varieties. However, the more fundamental problem is that fruit quality of these standard varieties does not satisfy the requirements of consumers.

Peach trees can be grown in nearly all regions of South Korea but late spring frost frequently becomes a limiting factor at higher altitudes. Kyongbuk province is the main peach production area with more than 50% of the total peach area, followed by Chungbuk (13.4%), Kyongnam (7.7%), and Chungnam (6.9%) (Table 5, Fig. 1). Full bloom typically occurs in Suwon about 20 April and about 1 week earlier in Kyongbuk Province. Fruit ripens from late June to mid-September. 'SunGlo' nectarine from the U.S. ripens about mid-August in Suwon.

Table 1. Fruit cultivation in hectares in Korea from 1985-1996 (7).

Kind	Year				
	1985	1990	1992	1994	1996
Apple	37,698	48,833	52,985	52,098	43,857
Persimmon	9,838	13,581	17,584	22,440	27,201
Grape	16,206	14,962	14,957	19,773	27,196
Citrus	15,688	19,287	22,413	22,233	25,423
Pear	9,022	9,058	10,339	12,649	18,243
Peach	13,138	12,333	10,635	10,166	10,002
Plum	4,029	3,191	2,933	2,670	3,053
Others	3,128	12,064	15,856	19,488	18,329
Total	108,747	133,309	147,702	161,517	173,304

Because the size of each orchard is small, about 0.5 ha on average, pruning, thinning, grading and packing are done manually. Moreover, fruits of mid- and late-ripening varieties are usually covered with paper bags mainly to inhibit the invasion of peach fruit moths (*Carposina niponensis* Walsingham). These cultural practices increase production costs. The most popular training system for peach trees is the open vase but recently the Y shape is gradually being adopted because of labor savings and convenience in maintenance. Tree spacing is 6 X 5 m for open vase and 6 X 2.5 m for Y shape. To control crop load, flower buds, blooms, and/or young fruits are thinned manually. Fruit is typically thinned to a uniform, preferred spacing on every shoot. Manual grading and packing is more common in Korea because fruit flesh of most varieties is soft and melting. However, small grading machinery is sometimes used for nectarines.

Wild peach seedlings are commonly used as peach rootstocks owing to their good seed germination. However, many nurserymen now depend on the seeds of *P. davidiana* Carr. imported from China for rootstock because of the short supply and high price of wild peach seed collected domestically.

Peach Breeding in Korea

History of Peach Breeding

Fruit breeding in Korea began in 1906 with the formation by the national government of the Horticultural Experiment Farm at Seoul. At that time, fruit "breeding," including peaches, mainly depended on the importation and testing of varieties from other countries. Fruit breeding programs using controlled hybridization have been carried out since 1957 following the establishment of the Horticultural Experiment Station (HES) at Suwon (Fig. 1) and an increase in the number of researchers. Early fruit breeding programs at the HES, the predecessor of the National Horticul-

Table 2. Fruit production (metric tons) in Korea from 1985-96 (7).

Kind	Year				
	1985	1990	1992	1994	1996
Apple	532,571	628,947	694,766	616,505	651,406
Citrus	370,543	492,676	718,955	548,961	514,053
Grape	149,912	131,324	146,346	211,930	357,274
Pear	128,079	159,335	173,511	163,729	219,322
Persimmon	97,031	95,758	155,111	167,471	210,866
Peach	131,544	114,578	115,792	114,837	127,540
Plum	33,505	25,211	22,630	20,764	28,678
Others	20,6261	18,419	63,129	85,413	98,000
Total	1,463,811	1,766,248	2,090,240	1,929,610	2,207,039

Table 3. Prunus species native or naturalized in Korea (6).

Species	Species
P. armeniaca var. *ansu* Max.	*P. Persica* (L.) Batsch
P. buegeriana Miq.	*P. salicina* Lindl.
P. glandulosa Thunb.	P. *salicina* var. *columnalis* Uyeki
P. japonica var. *nakaii* (Lev.) Rehder	*P. Sargentii* Rehder
P. leveilleana Koehne	*P. serrulata* var. *sontagiae* Nakai
P. maackii Rupr.	*P. serrulata* var. *spontanea* (Max.) Wils.
P. mandshurica var. *glabra* Nakai	*P. siberica* L.
P. maximowiczii Rupr.	*P. takensimensis* Nakai
P. mume S. et Z.	*P. tomentosa* Thunb.
P. padus L.	*P. triloba* var. *truncata* Kom.
P. pendula for. *ascendens* (Mak.) Ohwi.	*P. yedoensis* Matsumura

tural Research Institute (NHRI), which was reorganized in 1994, were mainly focused on apple and pear. Apple or pear breeders maintained concurrent but minimal peach breeding programs. Peach breeding was expanded in 1982 after the establishment of a new stone fruit breeding laboratory at HES. In addition, the Chungdo Peach Experiment Station (Fig. 1) was established in 1993 in southern Kyongbuk Province as an organization under the Kyongbuk Provincial Government. The station is responsible for both peach breeding and technical support for peach growers.

Although no private companies or colleges conduct peach breeding, a few enthusiastic fruit growers are releasing new varieties through selection of chance seedlings and natural sports. Passage and implementation in late 1995 of a new law related to plant patents is encouraging their participation in the releasing of new peach varieties. The law will ensure protection of breeder's rights for a new plant variety.

Breeding Goals

Peach breeding programs until now have been focused on the development of new varieties with fruit having high sugar, low acidity and large size (8). There are many unsolved problems relating to pests, diseases and climate, which should be overcome by breeding efforts.

In the development of new improved varieties, resistance to brown rot [*Monilinia fructicola* (Wint.) Honey] and bacterial leaf and fruit spot [*Xanthomonas campestris* pv. *pruni* (Smith) Dye)] are the major problems. Fruit scab [*Fusicladium carpophilum* (Thuem.) Oudem], leaf curl [*Taphrnia deformans* (Berk.) Tul.], scale (*Pseudoulacaspis pentagona targioni* Tozzetti, *Eulecanium kunoensis* Kvwana), aphids (*Myzus persicae* Sulzer, *Hyalopterus pruni* Geoffroy) and mites frequently cause some problems in peach growing but are not serious.

The rainy weather from late June to mid-July decreases fruit sweetness at har-

Table 4. Peach and nectarine cultivars grown commercially in Korea.

Ripening season	Cultivar	1987 (%)[z]	1992 (%)
Early	Kurakatawase	23.1	22.4
	Sunagowase	4.6	3.9
	Baekmijosaeng	0.8	1.0
	Others	4.7	3.1
	Subtotal	33.2	30.4
Mid	Okubo	11.2	10.5
	Mishima Hakuto	3.9	2.2
	Mibaekto	3.8	3.9
	Nakatsu Hakuto	2.4	2.3
	Hwangdo No .I	1.5	4.1
	Others	14.5	7.2
	Sub total	37.3	30.2
Late	Yumyeong	15.1	22.7
	Hakuto	11.1	11.1
	Shyuho[y]	1.4	2.9
	Others	1.8	2.6
	Sub total	29.4	39.4

[z]Percentage of total peach cultivation area.
[y]Nectarine.

Table 5. Korean regional peach cultivation and production (metric tons) in 1996 (7).

Province	Cultivation		Production	
	Area (ha)	Proportion (%)	Quantity (MT)	Proportion (%)
Kyongbuk	5,283	52.8	68,173	53.4
Chungbuk	1,334	13.4	15,821	12.4
Kyongnam	780	7.7	11,645	92
Chungnam	748	7.5	9,967	7.8
Chonbuk	519	5.2	6,820	5.4
Kangwon	407	4.1	5,230	4.1
Kyonggi	524	5.2	5,004	3.9
Chonnam	407	4.1	4,880	3.8
Total	10,002	100	127,540	100

vest, which is a common problem in white flesh peach varieties grown in Korea. To solve this problem, new germplasm needs to be found and utilized in future breeding programs. At the same time, physiological studies related to fruit sugar metabolism are needed.

The development of firm-fleshed varieties is also needed. Soft, melting-fleshed fruits are never desirable from a marketing standpoint. This fruit characteristic leads to post-harvest loss at every step from harvesting to final purchase by consumers. New varieties with melting but firm-fleshed fruit should be developed to decrease labor costs and reduce the time needed to handle soft fruit.

Although several new early-ripening varieties were released by the NHRI peach breeding program and via natural mutant selection, old early-ripening Japanese varieties are still widely grown. Almost all early-ripening varieties have defects such as split pits, short shelf life,

Table 6. Characteristics of new peach and nectarine varieties either released by, or evaluated by, the National Horticultural Research Institute in Korea (1, 2, 3, 4, 5).

Variety	Release year	Parentage	Bloom to ripening (days)	Flower type	Flesh color	Pit freeness	Flesh texture
Varieties Developed and Released by NHRI							
Yumyeong	1976	Yamatowase X Sunagowase	120	Showy	White	Cling	Nonmelting
Baekmijosaeng	1983	Mishima Hakuto X Sunagowase	63	Showy	White	Cling	Melting
Cheonhong[z]	1993	Garden State OP	100	Showy	Yellow	Free	Melting
Baekhyang	1995	Garden State OP	130	Nonshowy	White	Free	Melting
Grower Chance Seedlings Evaluated at NHRI							
Hwangdo No.1	1960	Chance sldg	110	Showy	Yellow	Cling	Nonmelting
Changhowon Hwangdo	1993	Chance sldg	145	Showy	Yellow	Cling	Melting
Grower Rud Sports Evaluated at NHRI							
Wolbongjosaeng	1987	Kurakatawase	75	Showy	White	Cling	Melting
Wolmiboksunga	1988	Yumyeong	95	Showy	Milky white	Cling	Nonmelting
Kuemkangkamdo	1997	Sunagowase	115	Showy	White	Cling	Melting
Chungmanjosaeng	1997	Yumyeong	65	Showy	Milky white	Cling	Melting
Wolhajosaeng	1991	Kurakatawase	70	Showy	White	Cling	Melting

[z]Nectarine.

low sugar level and small fruit size. Developing new early varieties in which those defects are ameliorated completely or partially, is also an important breeding goal.

Achievements of Peach Breeding Programs

Only a few new varieties have been developed by NHRI since 1957 (Table 6). Of them, 'Yumyeong' peach (5) and 'Cheonhong' nectarine have been of economic importance to the Korean peach industry. Several strains found as sports or chance seedlings by fruit growers have been released as new varieties (Table 6). Of them, 'Wolbongjosaeng' and 'Wolmiboksunga,' earlier ripening sports of 'Kurakatawase' and 'Yumyeong' respectively (2, 3) are widely planted.

Other Stone Fruits

Plums, apricots, and mume are also commercially grown. The cultivation areas of plums and apricots are not likely to increase because of 1) poor fruit quality and 2) the competition in the market with early ripening peach fruit.

All plum varieties grown are Japanese types. Popular varieties are 'Oishiwase,' 'Formosa,' 'Santa Rosa,' and 'Soldam.' Although NHRI has carried out a plum breeding program since the late 1980s, no new varieties have been released. The principal objective in the plum breeding program is the development of new early-ripening varieties that have high sugar content and large fruit. The four plum varieties mentioned above have been commonly used as parents in breeding.

Apricots are grown on a small scale. Traditional Korean (mostly *ansu* types) and old Japanese varieties such as 'Heiwa,' 'Miyasaka,' 'Hiroshimaomi' and 'Nngataomi,' are commonly grown. Their fruit qualities are not good in that fruit sweetness is low, fruit acidity is too high and fruit size is small. Rainy weather often causes cracking of ripening fruits. To encourage expansion of apricot growing, NHRI is also carrying out an apricot breeding program to eliminate those defects and to extend the harvesting season. Germplasm such as 'Harcot' and 'Tyrinthos' is considered good breeding material in the view of their desirable fruit characteristics.

Mume is grown for exportation as pickled fruit, extracted juice, and wine to Japan and for domestic wine production. It is grown in the southern part of the peninsula to avoid late frosts, because it blooms early. The most common varieties of mume are 'Shirokaga' and its seedlings because of their large fruit and good fruit set. Sweet cherry (*Prunus avium* L.) is grown in a few orchards, but the area of cultivation is very small.

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