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Trends in Public and Private Peach Breeding in the Republic of Korea

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Abstract

Peaches (including nectarines) are the fifth most important deciduous fruit in the Republic of Korea after apples, grapes, persimmons, and pears. Usually consumed as fresh fruit, 217,000 metric tons of peaches were produced in the country in 2015, and the total cultivated area was 16,704 ha. Peaches and nectarines account for 82% and 18%, respectively, of cultivated area in the Republic of Korea. The Republic of Korea's National Institute of Horticultural and Herbal Science (NIHHS), a division of the Rural Development Administration, initiated a public peach breeding program in 1961. The main purpose of this program has been to breed new peach cultivars to satisfy consumers and producers through the development of high-quality fruit and improved shelf life. 'Yumyeong', a white peach, was the first cultivar bred by the NIHHS, and was released in 1977. This peach has a good shelf life and firm flesh. To date, the NIHHS has released 10 peach and 4 nectarine cultivars through the national peach breeding program. 'Yumyeong' has been used as a main cross parent to improve fruit size, sweetness, and shelf life. It was a cross parent for 4 of the 10 peach cultivars bred by the NIHHS. The passage and implementation of the Seed Industry Law in December 1997 and subsequent membership in the International Union for the Protection of New Varieties of Plants has encouraged private breeders to release new cultivars. As a result, the number of such cultivars has increased annually. As of 2015, 108 applications for new cultivars have been submitted under the Plant Variety Protection legislation, and private breeders have released 87 of these cultivars. Most of these cultivars originated from bud sports of other key cultivars, such as 'Yumyeong', and chance seedlings.

Peaches (including nectarines) have a short shelf life compared with other fruit crops, and cultivars that can be harvested continuously are required for fresh produce markets. More than 60 cultivars are shipped to fresh markets from June to September in the Republic of Korea (Korea Statistical Information Service, 2016). Most peach farmers in the country cultivate more than 10 cultivars in their orchards and have expressed interest in planting new cultivars to generate more income. Moreover, with the growth of cultivation areas, demand for new and marketable cultivars is growing (Park et al., 2016).

The passage and implementation of the Seed Industry Law in December 1997 strengthened Plant Variety Protection rights. The enforcement of these rights has, in turn, promoted private breeding activity. Private breeding programs for peaches are the most active and dynamic among fruit crops, and breeders have continuously released new cultivars since 1998 (Korea Seed and Variety Service, 2016). Private breeders were responsible for 87 of the 108 peach and nectarine cultivars bred between 1998 and 2015 (Figure 1). Although breeding programs are active and productive in the Republic of Korea, few comprehensive reviews and reports on the subject are available. Thus, this review aims to provide an overview of the trends in public and private peach breeding in the Republic of Korea.

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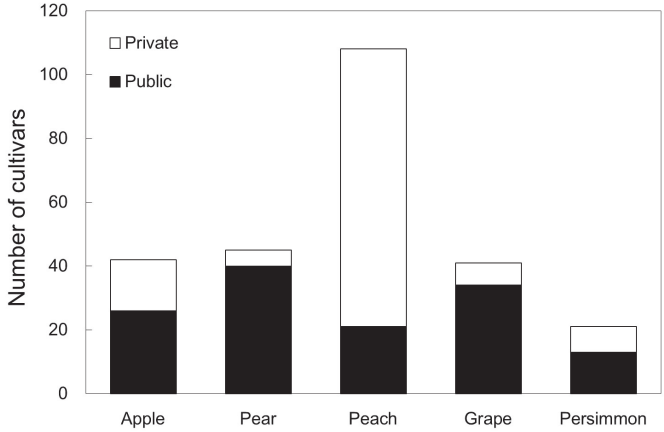

Fig. 1: The number of fruit cultivars submitted for Plant Variety Protection by public and private breeders between 1998 and 2015 in the Republic of Korea.

Peach and nectarine production

Peaches (including nectarines) are the fifth most important deciduous fruit in the Republic of Korea after apples, grapes, persimmons, and pears (Korea Statistical Information Service, 2016). Most peaches produced in the Republic of Korea are consumed as fresh fruit. About 2% of the total production volume is processed into products such as jams, beverages, and canned fruit (Park et al., 2016). The total planted area for peach trees has increased by 63.7% between 1995 and 2015 (Figure 2). This area is expected to grow another 13.8% between 2016 and 2025 (Park et al., 2016). Fresh fruit markets throughout the Republic of Korea are now open to imports from several countries and regions, including Chile, the United States, and the European Union, due to free trade agreements (FTAs). After the conclusion of a FTA between the Republic of Korea and Chile in 2004, the area used for peach cultivation in the Republic of Korea decreased between 2005 and 2009 (Figure 2). At that time, most farmers were concerned about fresh fruit imports from Chile. However, to date, no fresh peaches have been imported from any other country because of the Plant Protection Act. Compared with other fruit crops, peaches have a short juvenile period and maintain relatively high prices (Korea Statistical Information Service, 2016). These two features have led to an increase in the peach cultivation area, and thus increased peach fruit production. However, frost and freezing damage in 2010 and 2013 resulted in production declines of 30% and 17% compared with the respective previous years (Figure 2).

Peaches and nectarines account for 82% and 18%, respectively, of the cultivated area in the Republic of Korea. More than 70% of peach cultivars are white, non-acidic flesh, whereas most nectarines are yellow, moderately acidic flesh. The main peach cultivars are ‘Kawanakajima Hakuto’, ‘Changhowonhwangdo’, ‘Yumyeong’, and ‘Mibackdo’, and the primary nectarine cultivars are ‘Cheonhong’, ‘Redgold’, ‘Fantasia’, and ‘Sunfre’ (Korea Statistical Information Service, 2016).

Results of public peach breeding

The Republic of Korea’s National Institute of Horticultural and Herbal Science (NIHHS), a division of the Rural Development Administration, initiated a public peach breeding program in 1961 (Kim et al., 1978).

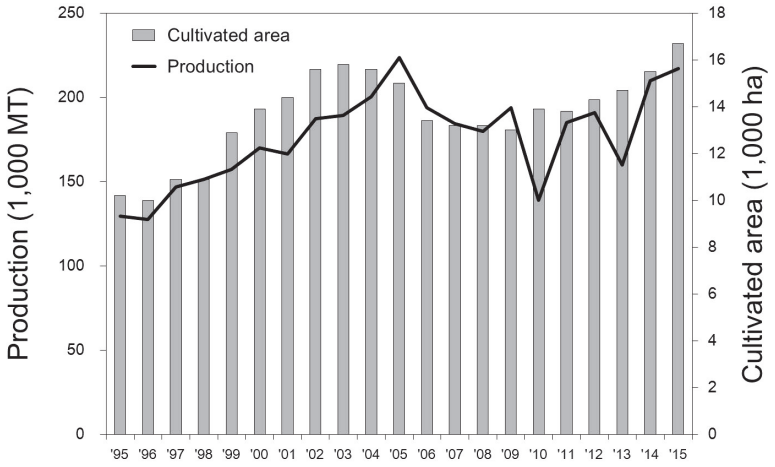

Fig. 2: Peach and nectarine production volume and total cultivated area in the Republic of Korea from 1995 to 2015.

The main purpose of this program has been to breed new peach cultivars to satisfy consumers and producers through the development of high-quality fruit and improved shelf life.

'Yumyeong' was the first cultivar bred by the NIHHS, in 1977 (Kim et al., 1978). As it has firm flesh, it is easy to handle during harvest and transportation. The amount of cultivation area devoted to 'Yumyeong' increased dramatically until the early 1990s. 'Yumyeong' occupied 23% of the total peach cultivation area in 1992. However, as consumers' preferences changed to sweet, juicy, and more soft-fleshed fruit, the cultivation area for 'Yumyeong' has decreased steadily (Jun et al., 2007a).

Although the popularity of 'Yumyeong' is decreasing, it has been a good resource for the improvement of fruit quality. 'Yumyeong' has been used as a main cross parent to improve fruit size, sweetness, and shelf life; it was used as a cross parent in 4 of the 10 peach cultivars bred by the NIHHS (Table 1). Besides, 'Yumyeong' has been used as a parent in other countries. 'Ghiaccio' peach series obtained by open pollination of 'Yumyeong' were released in Italy (Nicotra et al., 2002) and 'Coconut Ice' and 'Scarlet O'Hara' derived from 'Yumyeong' were released in New Zealand (Okie et al., 2008).

Before enforcement of the Seed Industry Law in 1997, new cultivars bred by public breeding programs were not protected. These cultivars were distributed to nurseries and farmers free of charge. At the time, the supply of new cultivars to domestic producers without charging them was popular, as taxes were used to fund public breeding programs. This approach was considered to be an efficient way to expand the number of new cultivars over a short period of time. That 'Yumyeong' and 'Chenhong' became the leading peach and nectarine cultivars, respectively, over a very short period of time may be a natural consequence of this practice (Jun et al., 2007a). These cultivars were distributed to nurseries and farmers free of charge from 1978 to 1993.

Another public peach breeding program has been developed by the Cheongdo Peach Experimental Station (CPES) and implemented by municipal governments. The CPES was established in 1994 in Cheongdo, North Gyeongsang Province, which is the main production region for peaches in

Table 1. Major characteristics of peach and nectarine cultivars released by public breeding programs in the Republic of Korea.

Cultivar	Release year	Parentage	Breeding program	Fruit type	Days to ripen from blooming	Flesh color	Flesh firmess	Reference
Yumyeong	1977	Yamatowase × Sunagowase	NIHHS	Peach	120	White	Stony hard	Kim et al., 1978
Baekmijosaeng	1983	Mishima Hakuto × Sunagowase	NIHHS	Peach	60	White	Soft melting	Kang et al., 1986
Cheonhong	1992	Open pollination of Garden State	NIHHS	Nectarine	100	Yellow	Soft melting	Kang et al., 1999a
Baekhyang	1994	Open pollination of Garden State	NIHHS	Peach	130	White	Soft melting	Kang et al., 1999b
Jinmi	1999	Hakuto × Nunomewase	NIHHS	Peach	125	White	Soft melting	Kang et al., 1999c
Daemyeong	2002	Bud sport of Yumyeong	CPES	Peach	110	White	Stony hard	Kwon et al., 2002
Suhong	2004	SunGlo × Cheonhong	NIHHS	Nectarine	115	Yellow	Soft melting	Jun et al., 2007c
Soomee	2005	Yumyeong × Chiyomaru	NIHHS	Peach	138	White	Soft melting	Jun et al., 2007d
Mihwang	2005	Kawanakajima Hakuto × Chiyomaru	CPES	Peach	78	Yellow	Soft melting	Choi et al., 2007
Mihong	2006	Yumyeong × Chiyomaru	NIHHS	Peach	77	White	Soft melting	Jun et al., 2007b
Chowhang	2007	Kawanakajima Hakuto × Chiyomaru	CPES	Peach	85	Yellow	Soft melting	Choi et al., 2008
Misshong	2008	Yumyeong × Chiyomaru	NIHHS	Peach	109	White	Soft melting	Jun et al., 2013a
Yumi	2009	Yumyeong × Chiyomaru	NIHHS	Peach	82	White	Soft melting	Jun et al., 2013b
Hahong	2009	SunGlo × Cheonhong	NIHHS	Nectarine	118	Yellow	Soft melting	Jun et al., 2014
Osubaekdo	2010	Unknown (chance seedling)	CPES	Peach	88	White	Soft melting	Park et al., 2014
Soohwang	2010	Nishio Gold × Chiyomaru	CPES	Peach	97	Yellow	Soft melting	Kim et al., 2010
Seonmi	2012	Hakuto × Baekhyang	NIHHS	Peach	114	White	Soft melting	Nam et al., 2012
Geumhwang	2012	NishioGold × Chiyomaru	CPES	Peach	93	Yellow	Soft melting	KSVS, 2016
Hwanghoo	2014	Open pollination of Changhowon Hwangdo	NIHHS	Peach	111	Yellow	Soft melting	Jun et al., 2014
Soobaek	2014	Okubo × Chiyomaru	CPES	Peach	80	White	Soft melting	Park et al., 2015
Seolhong	2015	Self-pollination of Baekhyang	NIHHS	Nectarine	134	White	Soft melting	NIHHS, 2015
Juwolhwangdo	2015	Bud sport of Hikawa Hakuho	CPES	Peach	80	Yellow	Soft melting	KSVS, 2016
Hongbaek	2015	Odoroki × Hikawa Hakuho	CPES	Peach	110	White	Soft melting	KSVS, 2016

NOTE: NIHHS, National Institute of Horticultural and Herbal Science; CPES, Cheongdo Peach Experiment Station; KSVS, Korea Seed and Variety Service.

the Republic of Korea. The CPES focused initially on developing of peach cultivation systems to achieve more stable and efficient production in North Gyeongsang Province. However, after public breeding programs began to raise money by patenting their releases, the CPES also focused on the release of new cultivars that were marketable and well adapted to the North Gyeongsang area. It released nine peach cultivars between 2002 and 2015 (Table 1). Although the history of the CPES' breeding program is short, the program has produced good results because of the advantage of its location in the district with the most production. Whereas most peach cultivars bred by the NIHHS are white fleshed, five of the nine cultivars bred by the CPES are yellow fleshed. Two cultivars released by the CPES originated from bud sports of 'Yumyeong' and 'Hikawa Hakuto'.

Of the 19 peach cultivars bred by the NIHHS and CPES, nine originated from the same cultivar, 'Chiyomaru', which was used as a male cross parent (Table 1). 'Chiyomaru' was bred in Japan and produces delicious, yellow-fleshed, early-ripening fruit (Yamaguchi et al., 1989).

Development of private peach breeding

Enforcement of the Seed Industry Law in 1997 and the Republic of Korea's entry into the International Union for the Protection of New Varieties of Plants encouraged private breeders to release new cultivars. Since that time, the number of such cultivars has increased annually.

As fruit breeding programs are long-term proejcts and require large fields and much capital, to be effective, the development of new cultivars is challenging for private breeders. However, peaches have a short juvenile period of 2–3 years, compared with the 5–10 years required for the maturation of most other fruit tree species. In addition, mutations commonly called bud sports are found frequently in peaches (Scorza and Sherman, 1996). As a result, private peach breeding is quite active compared with breeding of other fruit crops. More than 80% of the registered peach cultivars in the Republic of Korea

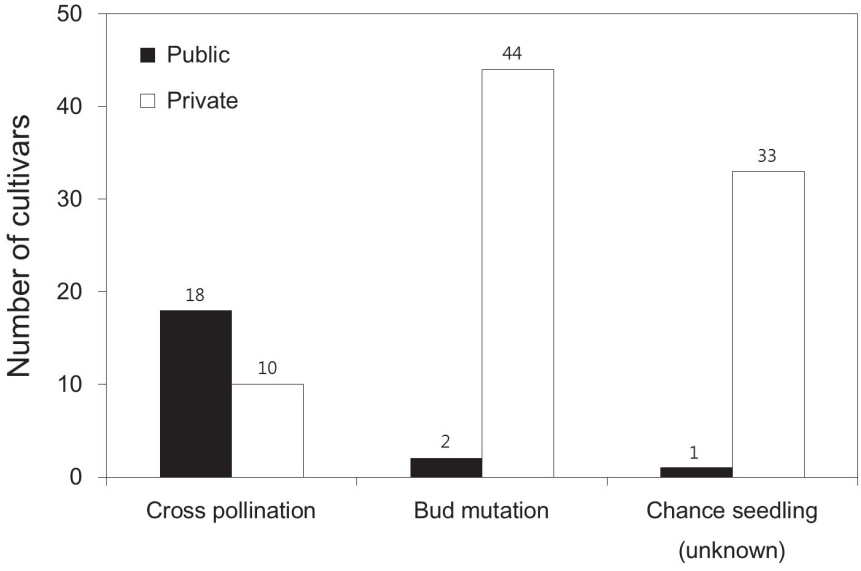

Fig. 3: Genetic origin and breeding programs of peach and nectarine cultivars released in the Republic of Korea between 1998 and 2015.

were released by private breeders (Figure 1). Of these 87 cultivars, 32 are yellow-fleshed peaches (Korea Seed and Variety Service, 2016).

Most cultivars released by private breeders originated from bud sports of the main cultivars, such as 'Yumyeong', or from chance seedlings with unknown parents. However, active private breeders currently try to select new cultivars from open-pollinated seedlings with known seed parents, or from cross pollination between two known cultivars (Figure 3).

Although private breeders have released 87 cultivars, few have become main cultivars (Korea Statistical Information Service, 2016). The development of main cultivars is not easy because most cultivars bred by private breeders have not been tested sufficiently to determine their qualities and adaptability to various regions throughout the country. For example, in 2010 and 2013, many new cultivars that came from Japan and private breeding programs experienced damage from freezing and frost in the northern regions of the Republic of Korea (National Institute of Horticultural and Herbal Science, 2015). Exaggerated promotion of new cultivars released by private breeders often results in the disappointment of farmers, who expect the new cultivars to be of high quality.

Conclusion

Much progress in peach breeding in the Republic of Korea has been achieved in the last 20 years. Active work continues in public and private breeding programs to meet the demands of fresh produce markets. Thus far, public and private peach breeding have been concentrated on the fresh domestic market. The extension of the harvest period and improvement of fruit size and sweetness are the main breeding targets in public and private programs.

However, trends in fruit consumption, production system practices, and orchard locations have been changing. Because consumers have become more aware of the health benefits of fruit, the potential exists to create a new market for cultivars developed specifically for health benefits, perhaps by incorporating "ingredients" such as carotenoids, anthocyanins, and polyphenols. The consumption of flat peaches is expected to increase because consumers are curious about this novel fruit and because these peaches can be eaten more easily than conventional round peaches. As trends in fruit consumption change, peach breeding programs should focus on high fruit quality, variety of fruit types, and possible health benefits. The high labor cost and the aging population of orchard workers are factors leading to the demand for easily cultivated new cultivars. Cultivars that exhibit dwarfing in rootstock or scion cultivars, good fruit firmness, and better post-harvest fruit characteristics are more important future breeding targets. As global climate change progresses, production areas are also changing. Cold-hardy and frost-hardy cultivars will be in great demand in the future. In the near future, low-chill cultivars may also be in demand. Most importantly, fruit breeders should be aware of the broad trends and focus on the development of reliable new cultivars to meet these needs.

Acknowledgements

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