JARQ 27, 33-37 (1993)

Persimmon Breeding in Japan

Masahiko YAMADA*

Akitsu Branch, Fruit Tree Research Station (Akitsu, Hiroshima, 729-24 Japan)

Abstract

Achievements of persimmon breeding at the Fruit Tree Research Station in Japan over 50 years were reviewed. The main objectives included the breeding of fruits with the following characters: pollination constant non-astringent type (PCNA), early ripening, high eating quality, large size and absence of physiological disorders such as fruit crackings. Crossing to obtain PCNA progenies was limited to PCNA types since the PCNA trait was recessive to the non-PCNA one. Moreover, only a small number of PCNA progenies could be obtained even in BC, since persimmon is hexaploid. Crossing was initiated among a small number of native PCNA cultivars, which were all late ripening and exhibited fruit cracking habits. Although the frequency of early ripening progenies in earlier stages was low, after several generations, the fruit ripening time in the maternal population became markedly advanced. However, since these progenies could be obtained only through inbreeding within a narrow gene pool, serious constraints such as the production of small fruits should be overcome.

Discipline: Horticulture
Additional key words: astringency, fruit, fruit cracking, inbreeding, ripening

Breeding at Fruit Tree Research Station

Persimmon (*Diospyros kaki* Thunb.) originated and has been mainly grown in China, Japan and Korea. Especially in Japan, it has been a major fruit crop for a long time, and even now, it ranks fifth in production. Therefore, many native cultivars have been developed all over the country.

The oldest national horticultural research station in Japan was established at Okitsu, Shizuoka, in 1902. Its present name is Okitsu Branch, Fruit Tree Research Station (FTRS), Ministry of Agriculture, Forestry and Fisheries (MAFF). More than 1,000 cultivars were collected and identified from all over the country. Fifty-seven cultivars including Fuyuu and Jirou were selected and recommended for production in 1912[1]. Subsequent efforts to introduce genetic resources from Korea and China enabled to identify a certain number of astringent cultivars, which were selected and recommended for extension but failed to gain the status of major cultivars in Japan.

The persimmon improvement program at Okitsu began in 1938, with emphasis placed on the improvement of the pollination constant non-astringent type (PCNA). Twenty-two PCNA selections derived from crossings among existing cultivars had been subjected to local adaptability tests in various districts all over the country. As a result, one cultivar was selected and released under the name of Suruga in 1959[4]. The fruits are late ripening, large with a cracking habit.

Thereafter, crossing among native cultivars and the resulting F_1s led to three PCNA selections, which were subjected to the second local adaptability test. Izu was selected among them and released in 1970[2]. The fruits are early ripening, with a high eating quality but cannot be well preserved. The tree is not vigorous and not productive. The total number of progenies examined at Okitsu was approximately 2,500.

Akitsu Branch of FTRS was established in 1968. The persimmon breeding program was carried over by the Akitsu Branch, thereafter. Orchards were established and seven PCNA selections of early to

*Present address : Okinawa Branch, Tropical Agricultuve Research Center (Isigaki, Okinawa, 907 Japan)

medium maturity within about 1,000 progenies were subjected to the third local adaptability test initiated in 1983. As a result, two PCNA cultivars were released under the name of Shinshuu and Youhou in 1990[11,12]. The former is productive and the fruits are early ripening with a high eating quality, but it experiences fruit-skin damage caused by pesticides and rain resulting in the softening and poor appearnce of the fruits. The latter is productive and the fruits are mid-ripening with a slightly harder flesh than that of Fuyuu. The fourth local adaptability test for the five PCNA selections initiated in 1989, is being carried out at 28 locations.

Cross-breeding has been performed at FTRS. The juvenile phase in persimmon is so long that top-grafting has been adopted to promote early fruiting and save the breeding space. Generally, the first fruiting occurs in the third or fourth year after top-grafting. Cumulative number of progenies top-grafted at Akitsu has been approximately 5,000 up to the present.

The program has been mainly focused on the breeding of fruits with early ripening, large size, high quality and absence of physiological disorders such as crackings. A few cultivars, Fuyuu, Jirou (non-astringent) and Hiratanenashi (astringent) and their strains accounted for a large proportion of persimmon production in Japan. Especially, early ripening has been emphasized due to the minimum in production in the early season.

Although early ripening natural budspores had been detected in major cultivars and planted for commercial production, they ripened earlier than the original ones by only 2 weeks.

Astringency of persimmon and mode of inheritance

Persimmons are classified into non-astringent and astringent cultivars, depending on whether the fruits lose their astringency on the tree at maturity. On the other hand, Hume[3] classified the persimmon cultivars on the basis of the darkening or lack of change of the flesh color under the influence of pollination, the former being referred to as pollination variant (PV) and the latter as pollination constant (PC), respectively. The non-astringent and astringent groups were commonly subdivided into PV and PC groups. Therefore the cultivars were classified into four groups, pollination variant non-astringent (PVNA), pollination constant non-astringent (PCNA), pollination variant astringent (PVA) and pollination constant astringent (PCA).

In the PCNA group, the mechanism of removal of astringency is different from that of the PV group. The tannins in the PCNA group are qualitatively different from those of the other groups[13]. On the basis of recent findings, Sugiura[7] proposed a new classification in which the cultivars are grouped into a volatile-independent group (VIG) and volatile-dependent group (VDG), the former corresponding to PCNA, and the latter including the other groups.

The inheritance of the astringency is controlled by two factors, the quality of the tannins and the ability of seed to generate the volatile compounds making the tannins insoluble, VIG being recessive to VDG[6]. The ability of seeds to generate the volatile compounds is quantitatively inherited.

Almost no progenies were derived from the crossing between the VIG and VDG groups, and among the VDGs of native cultivars. Crossing among the VIGs, resulted in all VIG progenies. When the F_1s of the VDGs derived from the crossing between VIGs and VDGs were backcrossed to VDGs, about 15% of VIGs occurred in BC_1. Since persimmon is hexaploid, the proportion is not likely to be high and therefore, crossing can be limited to the VIGs, when

Table 1. Frequency distribution of cultivars with fruit cracking at the calyx end and stylar end

Type	No. of cultivars	Severity of cracking[a]									
		Calyx end					Stylar end				
		0	1	2	3	4	0	1	2	3	4
Cultivars native to Japan											
PCNA	21	5[b]	7	4	3	2	6	8	2	5	0
PVNA	35	28	7	0	0	0	30	4	1	0	0
PVA	15	12	1	1	0	1	15	0	0	0	0
PCA	37	34	2	0	0	1	33	4	0	0	0
Cultivars introduced from Korea and China											
PCA	14	11	3	0	0	0	11	1	2	0	0
Total	122	90	20	5	3	4	95	17	5	5	0

a): Scores of cracking are as follows: 0; none, 1; minute, 2; slight, 3; medium, 4; severe.

b): Numbers of cultivars showing each degree of cracking.

the breeding objective aims at the development of superior PCNA new cultivars.

Characteristics of native PCNA cultivars

Crossing was initiated among the current PCNA cultivars only. There are 18 native PCNA cultivars except for budsports among about 300 cultivars which are preserved at Akitsu. Their origin is limited to the central area of Japan. There are almost no PCNA cultivars in the other countries. All of them are characterized by a late fruit ripening time, flat and typical fruit shape and fruit cracking both at the calyx end and stylar end. The PCNA cultivars are usually prone to crackings (Table 1). It is suggested that the PCNA cultivars are of recent origin and are undeveloped based on various records and findings[5].

It is difficult to develop early cultivars by crossing among late ripening PCNA cultivars. Moreover, fruit cracking is a major drawback for the breeding program[8].

However, many cultivars show large fruits and a high eating quality. Therefore, the progenies above selection criteria for eating quality, for example, the progenies with a fruit eating quality equal or superior to that of Fuyuu, accounted for more than two thirds of the progenies examined in 1987 and 1988[9]. Therefore, it is possible to develop new cultivars with a higher eating quality.

Even for the PCNA cultivars, complete natural removal of astringency is difficult to achieve. High temperature is required to remove the astringency. In the case of Fuyuu and Jirou the astringency can be easily removed and they can adapt to various areas unlike other cultivars.

Some of the persimmon cultivars show only female flowers, and others both female and male flowers. Although the main cultivars including Fuyuu, Jirou and their strains do not bear male flowers, many PCNA cultivars show male flowers including Okugosho, Hanagosho, Hazegosho, which are favorable for cross-breeding.

Advance in fruit ripening time

Fruit ripening time which is controlled by polygenes shows a high heritability[5]. It is difficult to obtain early ripening progenies by crossing

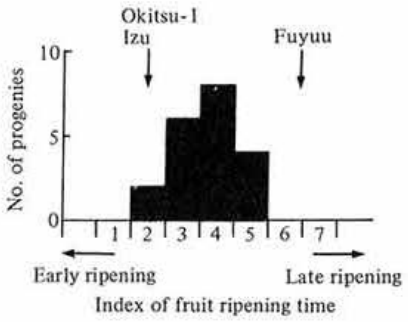

Fig. 1. Segregation of fruit ripening time in F_1 of Fuyuu × Okitsu-1[5]

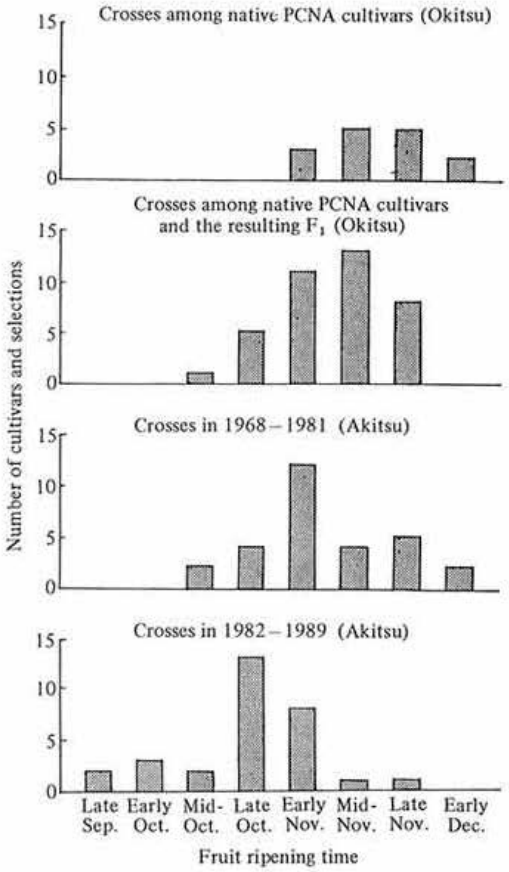

Fig. 2. Fruit ripening time of cultivars and selections of PCNA or derived from PCNA, used as parents at Okitsu and Akitsu

among late ripening cultivars. It was reported that, for example, the frequency of early ripening progenies had been 28% in crossing among early ripening cultivars, 8% among mid-ripening ones and 0% among late ripening cultivars.

First, early ripening maternal plants with male flowers were selected, and then crossed with superior late ripening cultivars such as Fuyuu. Izu was obtained from the above crossing. Okitsu-1 which was a selection (S_1) of Okugosho bears small and early ripening fruits. Izu was a hybrid between Fuyuu and Okitsu-1. However, the frequency of early ripening progenies was also low even in this crossing (Fig. 1). Moreover, new cultivars must display a high eating quality, large fruits, few physiological disorders and a high productivity. Therefore, the probability of obtaining a superior early ripening cultivar such as Izu is very low. For developing early ripening cultivars, both male and female parents must be even more early ripening.

Progress is being currently made in advancing the ripening time of the fruits of maternal populations. The numbers of PCNA cultivars and their progenies used as parents including those partly derived from Nishimurawase (PVNA) are shown in Fig. 2. After several generations, earlier ripening of the population could be achieved.

Other problems and prospects

The advance in the fruit ripening time in the maternal population has been attained through inbreeding over several generations. It is recommended to use cultivars and progenies with few defects as parents to release a new cultivar as early as possible. In particular, in persimmon breeding, originally, there were only a few superior PCNA cultivars. Repetition of the above crossing over several generations has resulted in inbreeding. Parents used in

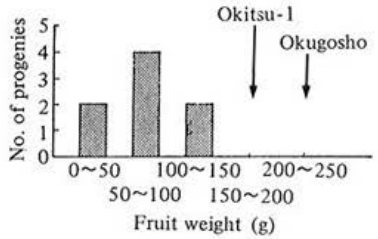

Fig. 3. Segregation in S_1 of Okitsu-1, which is S_1 of Okugosho

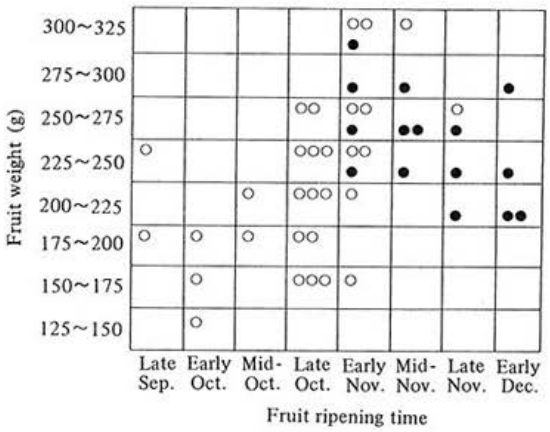

Fig. 4. Fruit ripening time and fruit weight in cross-parents at Okitsu and Akitsu
●: PCNA native cultivars used as parents at Okitsu.
○: PCNA cultivars and selections derived from PCNA, used as parents at Akitsu in 1982-1989.

1982-89 were all derived from only six PCNA cultivars and their strains (Fuyuu, Jirou, Okugosho, Hanagosho, Fukurogosho and Tenjingosho) and one PVNA (Nishimurawase). Moreover, 82% of them were derived from only five cultivars. Crossing has been repeated within a narrow gene pool.

Inbreeding results in a considerable reduction of the fruit weight[10]. For example, S_1s of Okitsu-1, which were the S_1s of Okugosho, were all very small, including progenies weighing even less than 50 g (Fig. 3). Fig. 4 shows a comparison in the fruit weight and fruit ripening time between PCNA native cultivars used as parents at Okitsu, and parental cultivars and selections used at Akitsu in 1982-89. Early ripening parents selected after several generations displayed small fruits.

Presently, at Akitsu, crossing is focused on mid-ripening with less inbreeding instead of early ripening, and on partly using PCNA late ripening cultivars with many defects and even non-PCNA cultivars as parents as a hastry breeding program may not enable to achieve the breeding objective.

Besides, progenies with whitish leaves and late fruit drop, which are not vigorous, have been recently observed in recent progeny populations, presumably due to inbreeding.

References

1) Agricultural Research Station, Ministry of Agr icultural Commerce (1912) : Investigation on persimmon cultivars. *Bull. Agr. Res. Sta.*, (extra), **28**, 1−46 [In Japanese].
2) Hirose, K. et al. (1971) : New Japanese persimmon variety "Izu". *Bull. Hort. Res. Sta.*, B**11**, 1−17 [In Japanese with English summary].
3) Hume, H. H. (1914) : A kaki classification. *J. Heredity*, **5**, 400−406.
4) Iikubo, S., Sato, T. & Nishida, T. (1961) : New Japanese persimmon variety "Suruga". *Bull. Hort. Sta. Nat. Tokai-Kinki Agr. Exp. Sta.*, **6**, 33−37 [In Japanese with English summary].
5) Ikeda, I. et al. (1975) : The inheritance of some characters in Japanese persimmon. 3. The inheritance of season of ripening. *Bull. Fruit Tree Res. Sta.*, B**2**, 1−20 [In Japanese with English summary].
6) Ikeda, I. et al. (1985) : Inheritance of astringency in Japanese persimmon. *J. Jpn. Hort. Sci.*, **54**, 39−45 [In Japanese with English summary].
7) Sugiura, A. (1983) : The origin and cultivar differentiation in persimmon. *Recent Advance in Breeding*, **25**, 30−37 [In Japanese].
8) Yamada, M. et al. (1988) : Inheritance of fruit cracking at the calyx end and stylar end in Japanese persimmon. *J. Jpn Hort. Sci.*, **57**, 8−16 [In Japanese with English summary].
9) Yamada, M. (1989) : Persimmon breeding aiming at early ripening and its prospect. *In* Abst. Jpn. Soc. Hort. Sci. Symp. 1−9 [In Japanese].
10) Yamada, M., Yamane, H. & Yoshinaga K. (1991) : Studies on crossbreeding in Japanese persimmon. 7. Genetic analysis of fruit weight. *J. Jpn. Hort. Sci.*, **59** (suppl. 2), 216−217 [In Japanese].
11) Yamane H. et al. (1991) : New Japanese persimmon cultivar "Shinshuu". *Bull. Fruit Tree Res. Sta.*, **19**, 13−27 [In Japanese with English summary].
12) Yamane H. et al. (1991) : New Japanese persimmon cultivar "Youhou". *Bull. Fruit Tree Res. Sta.*, **20**, 49−61 [In Japanese with English summary].
13) Yonemori, K., Matsushima J. & Sugiura, S. (1983) : Differences in tannins of non-astringent and astringent type fruits of Japanese persimmon. *J. Jpn. Hort. Sci.*, **52**, 135−144 [In Japanese with English summary].

(Received for publication, Jan. 25, 1993)