Trend of Breeding Works for Japanese Pear in Japan

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Japanese pear (*Pyrus serotina* Rehder) is a traditional fruit tree from ancient times. Its seeds were discovered in the Toro-ruins, which is regarded archeologically as of the late Yayoi-era. A record that its cultivation is encouraged was found in the chapter of Emperor Jito (693 A.D.) in an ancient manuscript, Nihon-shoki. However, it was in the middle Edo era that the concept of varieties, and cultural techniques were developed: description of many varieties was recorded in 1735.

Development of cities and transport facilities has promoted the appearance of chief producing areas. With the successive discovery of two leading varieties, Nijisseiki and Chōjūrō, in about 1895, chief producing areas have developed mostly for these two major varieties. At present, the total planted area and production of Japanese pear account for 19,100 ha and 490,000 tons, respectively. It ranks second after grape as a fruit for the summer—autumn season.

As given in Table 1, which shows planted areas by varieties, the two major varieties, Nijisseiki and Chōjūrō, were predominant in 1960's, but in 1970's new varieties such as Shinsui, Kōsui, and Hōsui, all developed in the National Horticultural Research Station began to increase. It is expected that these three varieties will constitute 30% of the total planted area in 1980's.

Pioneering works in Japanese pear breeding

Two apparent directions of varietal improvement recognized from the transition of varieties are for the earliness and better fruit texture. Improvement of texture is inevitable with

Table 1. Long-term changes in planted area of pear cultivars (ha)

Cultivar	1929	1936	1947	1953	1958	1974	1981[a)]
Chōjūrō[b)]	5,042	5,376	2,168	3,087	4,876	5,936	5,303
Nijisseiki[c)]	844	1,527	1,978	3,363	5,503	6,675	7,054
Waseaka	1,637	1,446	854	748	575	—	—
Okusankichi	1,141	1,115	666	554	453	123	97
Yakumo		232	257	526	770	456	482
Kikusui		248	202	480	270	168	134
Shinsui[d)]						705	2,435
Kōsui[e)]						1,414	4,024
Hōsui[f)]						361	2,160
Shinkō				71	—	271	315
Total	11,138	12,169	7,076	9,873	14,700	18,773	24,732

a) Estimate
b) A leading variety of russet fruit type
c) A leading variety of green fruit type
d) Variety released from Fruit Res. Sta. in 1965
e) Variety released from Fruit Res. Sta. in 1959
f) Variety released from Fruit Res. Sta. in 1974

Japanese pear, which is called sand pear. The fact that Nijisseiki occupied 35% of the total planted area of Japanese pear, in spite of its extreme susceptibility to black spot disease that makes its cultivation impossible without bagging, is based on the superiority of texture of this variety. With such historical background, the first breeding work in the Horticultural Research Station was hybridizations made by Tanikawa between Japanese pear and European pear (*Pyrus communiss* LINN.) and between Japanese pear and Chinese pear (*P. Bretschneideri* Rehder or *P. sinensis* Lindley). The work started in 1909 and finished by 1925, but no variety better than before was obtained.

A breeding program planned by Kikuchi, was initiated in the Kanagawa Prefectural Hortricultural Experiment Station in 1915. By 1919, hybridizations using a total of 33 varieties including 23 Japanese, 1 Chinese, and 9 European varieties and hybrids, were made to give 1,310 hybrid seedlings. From them, Yakumo, an early maturing, non-russet type variety resistant to black spot disease, Kikusui, a medium-maturing variety and Niitaka, a late-maturing russet type variety, were selected and released in 1927. Among them, Yakumo and Kikusui have been used as important parents for later breeding programs.

Start of systematic breeding works in national research station

In 1935, the breeding of Japanese pear was taken up as one of the important research projects in the Horticultural Research Station. With a breeding objective to develop black spot disease resistant varieties with excellent fruit texture like that of Nijisseiki, a large number of crosses between traditional varieties were made as the first hybridization program, and 1,761 hybrid seedlings of 55 combinations were obtained.

1) *Varieties developed by the first hybridization program, and related researches on breeding*

From the hybrid seedlings of the first hybridization program, 11 selections were obtained in 1949, and they were subjected to adaptability tests using their scions. The tests were carried out at 9 places, including 8 metropolitan and prefectural stations. New varieties, Kumoi and Suisei, were released in 1955, and Kōsui in 1959. Although Kōsui has a shortcoming that its flower bud formation ability is somewhat less and hence productivity seems somewhat less, it was released by considering that it is a russet type earlier than Chōjūrō, better than Nijisseiki in texture of fruit which is juicy and sweet, and resistant to black spot disease, At present, it becomes a leading variety of early russet type pear, being planted throughout the country.

Results of measurement of fruit characteristics made at the time of release of Kōsui were complied by Mori[10]. He regarded that the Kikuchi's theory can almost appropriately be applied to the heredity of rind color, and also that the frequency of occurring such excellent texture like Nijisseiki is extremely low. So that he emphasized the need of using both parents with texture comparable to that of Nijisseiki. This proposal has influenced later hybridization programs.

2) *Varieties developed by the second hybridization program*

Hybridization started from 1947, giving 971 seedlings of 37 combinations. They began to flower from 1953, and the second adaptability test with 3 selections was carried out in 1956. To the test, 9 metropolitan and prefectural stations participated. In 1965, Shinsui was released[2]. This variety, a russet type earlier than Kōsui by 10 days, was released because of its excellent quality although its resistance to black spot disease and productivity are somewhat less. In 1968, Hayatama was released.

3) *Varieties developed by the third hybridization program, and research on breeding in the program period*

In 1953–1955 hybridization among improved selections and released varieties developed by the first and second programs were made, and

3,300 seedlings were obtained. Among them, 8 lines were selected and subjected to the third adaptability test, to which 25 metropolitan and prefectural stations participated.

During that period, histological and chemical studies on texture were carried out by Machida and Maeda[6], and Machida and Tashiro[7]. It was made clear that the texture of Japanese pear is more strongly influenced by flesh firmness than density of stone-cell clusters, and the measurement of firmness was proposed as a simple method of quantitative expression of texture. It was also found that there is a high positive correlation between flesh firmness and hollocellulose contents with different varieties or with a same variety grown at different places.

A genetical study on black spot disease resistance, made by Kozaki[4,5], revealed that the resistance and susceptibility are determined by a pair of allelic genes, with the susceptibility being dominant. Resistant varieties are recessive-homo, while all susceptible varieties are hetero. It is interesting that there is no dominant-homo variety. Screening for resistant plants can be made with certainty by spraying spore-suspension to seedlings one month after seed germination. This method has contributed greatly to increase the efficiency of breeding work.

The third adaptability test continued for 8 years, and Hakkō and Hōsui were released in 1972[3]. Hōsui, a medium-maturing russet type, is later than Chōjūrō by about 5 days, extremely excellent in quality with sweetness, and resistant to black spot disease. Its cultivation is easier than Shinsui and Kōsui, and it is now spreading mainly in the Kanto region. It is expected to become a leading variety in furture.

An analysis by statistical genetics was made by Machida and Kozaki[8,9] on 4 traits, flesh firmness, brix, pH, and fruit weight, using combinations randomly selected from hybrid seedlings of the third hybridization program. Using the Falconer's random-mating population model, they estimated the heritability of each trait by means of the full-sib population analysis and offspring-mid-parent regression. The flesh firmness showed the highest heritability, $h^2=0.6-0.7$, followed by 0.5—0.6 for pH, and 0.05—0.1 for fruit weight. Based on these results, they proposed actual method of selecting parents for hybridization and rational method of selection works, which contributed to systematize the breeding of Japanese pear.

4) *Implementation of the fourth adaptability test*

From the hybrid seedlings developed by the third hybridization program, 9 lines were further selected in 1972, and the adaptability test is now in progress.

5) *The fourth hybridization program and related researches on breeding*

Taking the removal of the National Fruit Tree Research Station from Hiratsuka to Tsukuba into consideration, crossings were made in 1970–1976, and 2,047 hybrid seedlings of 71 combinations were developed. Examinations on their fruit were started in 1978.

As to research side, a diallel cross program, consisted of 7 varieties was designed, in which a total of 882 plants including 42 combinations and parent varieties were grown in 0.4 ha orchard by the randomized block design with two replications to study combining ability and genetic correleration with regard to fruit quality, tree characteristics, disease resistance and other characters related to productivity.

In addition, genetic studies on rust disease resistance and necrotic leaf spot virus tolerance are in progress, and also thremmatological researches on scab resistance and canker resistance are being planned.

On the other hand, it is planned to take up a study on varietal differences in dry matter production and in photosynthetic potential, in relation to productivity, in 1979.

Present breeding works in prefectural stations

Breeding of Japanese pear has continued since 1915 in the Kanagawa Prefectural Horticultural Experiment Station. In 1976, an extremely early-maturing russet type variety,

Chōju, was released from the station.

An early-maturing russet type variety, Tama which was released from the Tokyo Metropolitan Agricultural Experiment Station in 1971 has attracted growers attention in certain areas, due to considerably good quality and easiness of cultivation by growers.

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