Comparisons in the Variations in Fruit Maturing Time, Fruit Weight, and Soluble Solids Content of Oriental Persimmon Cultivars of Chinese and Japanese Origin

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Summary

Fruit maturing time (FMT), fruit weight (FW), and soluble solids content (SSC) were evaluated for 83 pollination-constant astringent oriental persimmon (Diospyros kaki Thunb.) cultivars of Japanese origin at Akitsu, Hiroshima, Japan, and 132 cultivars of Chinese origin at Meixian, Shaanxi, China. The data on FMT and FW were adjusted by adding correction constants for the effect of location. Results showed that there were little differences in the mean and variation between the cultivar groups of the two origins for FMT and FW. There was a small difference in the mean SSC, although the variance was larger in the Chinese than in the Japanese cultivars.

Introduction

To begin a cultivar improvement program, the place of and the variations within the genetic resources should be described first so that an effective selection strategy can be attempted. A useful pool of genetic materials can then be introduced and used for hybridization.

A firsthand examination of genetic resources in a foreign country is difficult, it is inappropriate to introduce cultivars whose characteristics are not well known. Often, however, the genetic resources have already been evaluated in the country of origin. If that information can be correlated with that of another country, cultivars can be identified as to whether or not they have a potential as parental breeding stocks.

There are numerous cultivars of oriental persimmon (Diospyros kaki Thunb.), especially in China with its long history of persimmon culture; in Japan two types of non-astringent cultivars, pollination-constant and -variant (Kitagawa and Glucina, 1984; Yamada, 1993) have been developed. The oriental persimmon was the primary fruit crop for a long time in Japan. The genetic pools of the two countries represent a major collection of the species.

In Japan, a large number of native cultivars were collected and evaluated; the leading cultivars such as 'Fuyu', 'Jiro' and 'Hiratanenashi' were selected in the beginning of the 20th century (Agr. Res. Sta. Bull., 1912). The collection is still preserved and reevaluated at the Akitsu Branch of the Fruit Tree Research Station (FTRS), Akitsu, Japan.

In China, more than 900 domestic cultivars have recently been collected and evaluated for synonyms by Wang and his group at the Experimental Farm of the Pomology Institute, Shaanxi Academy of Agricultural Sciences, Meixian, Shaanxi, China. They evaluated characteristics of 132 cultivars which did not include any synonyms, and found that the persimmon cultivars originating in China are all of the pollination-constant, astringent type with the exception of 'Luo
Kikuchi (1948) stated that, according to Ho, there were only 50~60 domestic cultivars in China, these were astringent and inferior to the Japanese cultivars. But, the size of the genetic pool is far larger than that estimated at that time. Persimmons, being endemic to China, a huge country with varying climates, are widely dispersed. Hence, it is unlikely that only a small variation exists among the Chinese cultivars.

In Shaanxi province, China, persimmon fruit are harvested and sold in early September; whereas in Japan the earliest fruit are harvested in late September for trees grown outdoors. It is possible that very early maturing cultivars which do not exist in Japan, exist in China. However, fruit maturing time (FMT) varies greatly according to locality; likewise fruit weight (FW) and soluble solids content (SSC), which are quantitative measures, exhibit large environmental fluctuations.

The climate and cultural practices are different between Akitsu and Meixian, so that a direct comparison of data for genetic resources obtained at the two sites cannot be made. However, they may be made comparable if, as we reported (1995), the data on cultivar performance at one location is suitably adjusted by adding a correction constant for FMT and FW.

The purpose of this study was to compare the variations in oriental persimmon cultivars of Chinese and Japanese origin by integrating data obtained in the two countries.

Materials and Methods

In Japan, 83 pollination-constant, astringent (PCA) cultivars (Yamada, 1993) of Japanese origin were evaluated at Akitsu Branch, Fruit Tree Research Station during 1987~1992 (Yamada et al., 1994b). The trees were dormant-pruned; the flower buds and fruit were thinned, and the crop was evaluated for FMT, FW and SSC according to Yamada et al. (1995). FMT was judged to be the time when the largest number of fruit with the best eating quality was harvested. FMT was rated on a scale of 1 to 8; a rating of 1 corresponded to late September, 2 to early October, 3 to mid-October, 4 to late October, 5 to early November, 6 to mid-November, 7 to late November, and 8 to early December.

Usually 15 fruit were sampled and their mean FW were log-transformed as reported earlier (Yamada et al., 1993). After removing the astringency with 35% ethanol, a small volume of juice was pressed from the equatorial portion of each fruit from which the SSC was determined with a calibrated refractometer (Model No.N1, Atago, Inc., Tokyo, Japan). Although FW and SSC fluctuate yearly, each cultivar was evaluated only once with an annual repetition and the data adjusted to reduce yearly variation as reported earlier (Yamada et al., 1994a, 1995).

At Meixian, 132 PCA cultivars of Chinese origin were evaluated during 1986~1990. Individual trees were dormant-pruned but blossom and fruit thinning were not practiced. FMT was determined as the fruit became fully colored and the seed coat darkened. The average weight was obtained from approximately 20 fruit and their SSC determined refractometrically after leaving fruit until the astringency disappeared.

The FMT and FW values of the Chinese cultivars were adjusted for the differences due to cultivation, climate, and evaluation between Akitsu and Meixian by adding the correction constant of FMT + 1.76 and log FW + 0.162 according to Yamada et al. (1995). The adjusted values show the estimates in cultivation and evaluation at Akitsu for the Chinese cultivars. The values for SSC were not adjusted as there were no significant differences between locations (Yamada et al., 1995).

Results and Discussion

All cultivars of Chinese origin are PCA type, with the exception of one, 'Luo Tian Tian Shi' (Wang et al., 1982; Yamada et al., 1993b). Cultivars of Japanese origin were of four types: PCA, pollination-variant, astringent type (PVA), pollination-constant, non-astringent type (PCNA), and pollination-variant, non-astringent type (PVNA) (Kitagawa and Glucina, 1984; Yamada, 1993). The latter three groups were presumed to be derived from PCA in more recent times, and their variations in FMT, FW and SSC were no greater than those of PCA (Yamada et al., 1994b). Therefore, a comparison of the variation between Chinese and Japanese cultivars of the PCA provides non-biased information.
1. Fruit maturing time

The mean FMT of the 132 Chinese cultivars was 3.7, however, with the addition of a correction constant for cultural and environmental differences at Akitsu, it became 5.4 (Table 1). The mean value of Japanese origin cultivars was 5.8, so that the difference between them was minimal.

Late maturing cultivars, collected from various districts in China did not separate well within the late maturing time at Meixian because of the cool temperature after late October. The frequency distribution of cultivars was made by grouping late maturing cultivars; the FMT then exceeds 5 after the adjustment (Fig. 1A). In general, there was little difference in the frequency distribution of FMT between Chinese and Japanese cultivars.

We found that the genetic resources preserved in both Meixian and Akitsu had similar FMT variations. Most cultivars evaluated at Meixian originated mainly in the region between 30° and 40° N (Fig. 2), which is the most productive area in China (Wang, 1987). Japanese cultivars are also found at the same latitude. Yamada et al. (1994b) reported that the percentage of early maturing cultivars (maturing in October) increases as the originating area moved northward. No early maturing cultivar was found among those originating in the sub-tropical regions of China. The similarity in variations between Chinese and Japanese cultivars is attributed to their being endemic to areas in the same latitude north. If many Chinese cultivars from southern China had been collected and evaluated, the frequency distribution of FMT might differ considerably.

There are only a few Chinese cultivars preserved at Meixian that mature in October in Japan, although the target of the persimmon improving program in FTRS, Japan is to develop early maturing genotypes (Yamada, 1993).

2. Fruit Weight

After adjusting for site differences, the mean FW of the Chinese cultivars increased from 133g to 194g; hence it approaches the 190g mean of the Japanese cultivars (Table 1). The variance in the Chinese was slightly larger than in the Japanese, but the difference was not significant at P=0.05 (Table 1). The frequency distribution of FW for the sites was also similar (Fig. 1B). The environ-

Fig. 1. Frequency distribution of persimmon cultivars of Chinese (solid column) and Japanese origin (open column) in fruit maturing time index (A), fruit weight (B) and soluble solids content (C). For fruit maturing time index, a rating of 1 corresponded to late September, 2 to early October, 3 to mid-October, 4 to late October, 5 to early November, 6 to mid-November, 7 to late November and 8 to early December. Arrows indicate the positions of representative cultivars; ①Raotianhong, ②Jumishi, ③Mopanshi, ④Ichidagaki, ⑤Saijo, ⑥Atago.
mental variance in Chinese cultivars may be large because the crop loads were not thinned to adjust the leaf/fruit ratio as they were at Akitsu. The variation seemed to be nearly the same in Chinese and Japanese cultivars, suggesting that the selection pressure was historically similar in both countries.

At the present time, small-sized fruit are not commercially desirable in Japan; this is not true in China. In Japan, commercial production was developed only in this century; previously, there may not have been a demand for large fruit. Small fruit may be more suitable to make dried persimmons which were more widely consumed in the past.

Fig. 2. The origin of cultivars evaluated in the present study. The origin of eight Japanese cultivars is not exactly known and, therefore, not included in the figure.

### Table 1. Mean and variance of fruit maturing time, fruit weight and soluble solids content in oriental persimmon cultivars originated in Japan and China.

<table>
<thead>
<tr>
<th>Origin</th>
<th>No. of cultivars</th>
<th>Fruit maturing time</th>
<th>Fruit weight</th>
<th>Soluble solids content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>83</td>
<td>5.8</td>
<td>190 g</td>
<td>16.8 %</td>
</tr>
<tr>
<td>China</td>
<td>132</td>
<td>5.4</td>
<td>194</td>
<td>17.7</td>
</tr>
</tbody>
</table>

- Variance was not compared because late maturing cultivars originating in China were not separated at Meixian due to the rapid decrease of temperature in autumn.
- The variance for values transformed to log.
- Variance separation by F-test, P = 0.05.
3. Soluble solids content

The mean SSC in the Chinese and the Japanese were 17.7% and 16.8%, respectively (Table 1). The difference may be small, considering the wide range of SSC variations. An insignificant difference for the site effect was found in SSC (Yamada et al., 1995), suggesting a large environmental or interaction effect between the location and genotypes. A yearly fluctuation of 1~2% is common at Akitsu (Yamada et al., 1994a).

The variance was much larger in the Chinese (9.5) than in the Japanese cultivars (2.4) (Table 1 and Fig. 1C). SSC is strongly influenced by environmental factors (Yamada et al., 1993a, 1994a), and the different methods of evaluation between locations may contribute to the variance. It is, therefore, difficult to discuss the differences in the genetic variance.

The environmental variance and heritability in a broad-sense for SSC of Japanese cultivars were calculated as 0.56 and 0.8, respectively, using the environmental variance components obtained earlier (Yamada et al., 1993a); no environmental variance was obtained for the Chinese cultivars. If Chinese and Japanese cultivars had the same genetic variance, the heritability in Chinese cultivars would be estimated as 0.2. Thus, if the Chinese cultivars had more than 0.2 heritability, their genetic variation would be larger than that for the Japanese cultivars.

4. General discussion

The results indicate that the Chinese and Japanese cultivars preserved at Meixian and Akitsu had similar variations in FMT and FW. The differences between the means, including that of SSC, were not pronounced which suggest that selection pressures in China and Japan were nearly the same during the evolution of persimmon culture.

It is believed that persimmon existed even in the diluvial epoch in Japan, because remains of the fruit were found in diluvia (Sobajima, 1980). However, no persimmon remains have been found in ruins prior to the third century, and the persimmon is not mentioned as a fruit crop in the eighth century literature such as the 'Kojiki', 'Nihonshoki', or 'Manyoshu', although other fruits are (Sobajima, 1980). Ikegami (1964) hypothesized that the persimmon in Japan once disappeared, and was improved based on persimmons introduced from China after the eighth century, when Chinese culture was frequently accepted by the Japanese. According to Kikuchi (1948), the first Japanese literature describing persimmon as a fruit crop was written in the 10th century.

Even if the present Japanese cultivars developed based mainly on those introduced from China, seeds may have been introduced because of the impossibility of scion transportation long ago. If that is so, these imported seedlings served as a source of open-pollinated chance seedlings from which selections were made.

Persimmon culture in China was described in 'Shang Lin Fu' which was written around B.C. 120 (Wang, 1987), illustrating the long history of persimmon culture in China. It is natural that the Chinese cultivars with a longer history and grown in a wider area, have larger variations than have the Japanese cultivars.

But, the adjusted variations between the Chinese and Japanese cultivars are similar for FMT and FW, which suggests that a rapid cultivar development occurred in Japan. In Japan, with a high rainfall, persimmon would have a high value as a fruit crop, unlike in China where other fruit crops are also adaptable. This climatic difference may have led to the rapid cultivar development in Japan, and account for the development of a large number of preferred non-astringent cultivars, especially of the PVNA type.

The PVNA cultivars which appeared in Japan are first mentioned in some 13th century literature (Kikuchi, 1948). However, this group has a variation similar to that of the PCA group and distributes all over the country, suggesting a rapid development and dissemination (Yamada et al., 1994b).

PVNA fruit needs seed formation for astringency to disappear on trees. Often the fruit contain several seeds. Open-pollinated, chance seedlings from these seeds undoubtedly gave rise to numerous PVNA. PCA seedlings are also obtained from crossings between PVNA, and from crossings among PVNA, PVA, PCNA, and PCA (Ikeda et al., 1985). It is natural that some present PCA cultivars in Japan were partly derived from PVNA ancestors. Those open-pollinated chance seedlings may have contributed to the rapid development and disper-
Cultivar development is slower in China where PVNA cultivars do not exist. For a stable production, parthenocarpic cultivars may be preferred. If so, bud-mutation may have been more important in the cultivar development in China.

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Literature Cited

中国および日本原産のカキ品種における果実成熟期、果実重および可溶性固形物含量の変異の比較

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摘要

中国原産のカキ（Diospyros kaki Thunb.）132 品種と日本原産の 83 品種をそれぞれ中国陝西省眉県と日本国広島県安芸津において栽培し、果実成熟期、果実重および可溶性固形物含量を調査した。これらのカキはすべて pollination constant の流加であった。果実成熟期と果実重の場所間の変動は、中国品種の成績に両場所間の補正定数を加えることによって補正した。その結果、果実成熟期と果実重については、両国原産のカキ品種における平均値と変異にほとんど差がなかった。可溶性固形物含量については、両国品種の間の平均値の差異は小さかった（0.9%）が、分散は中国品種の方が日本品種よりも大きかった。

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