

The Status of *Fortunella* Genetic Resources in China

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Abstract: The genus *Fortunella* has been cultivated in China for at least 1700 years and apparently, reached an advanced stage in the Tang Dynasty (618-907) and Song Dynasty (960-1279). According to early Chinese references about *Fortunella*, it was distributed in 6 provinces. The use of trifoliate orange as a rootstock for kumquat propagation was recorded in the 13th century. There are many cultivars and clones of 6 known species which originated in China. The kumquat is utilized for fresh fruits, candied fruits and potted ornamental plants. It was found that *Fortunella hindsii* var. *chinotou* is a promising dwarf rootstock for citrus.

Introduction

Fortunella, *Citrus* and *Poncirus* are the 3 most important genera in the orange subfamily, Aurantioideae. *Citrus*, the most important genus, has a great number of species and cultivars, and grows in many areas having tropical and subtropical climates. *Poncirus* has only one species and its fruits are not edible. It is an important rootstock for edible citrus. *Fortunella* is another relative of citrus, and at one time, it was included in the genus *Citrus* by taxonomists. The plant is small and produces small fruits with edible peel. The tree is planted as a fruit tree and also used as an ornamental plant in China. *Fortunella* is an important citrus genetic resource, because it is more cold hardy than other evergreen citrus plants and has edible fruit. It is widely distributed in the southeast part of China. Unquestionably, *Fortunella* originated in this area.

HISTORY

In early Chinese literature, a number of common names were applied to *Fortunella*, which includes Jingan, Jinju (kumquat), and Xianju (Fairy mandarin). Linhaiywuzhi (The annals of strange information), Bowuzhi (The records of natural science), and Guangzhi (The monograph of Kwang Province), published in the third century (3), are the earliest references recording the fruit characters and growing districts of *Fortunella*. It is known that *Fortunella* had been widely grown and apparently reached an advanced stage of cultivation in the Tang Dynasty and in the Song Dynasty. Duan Gong-lu stated that in Beihulu (ca. 9th century): "The flavor of the fruit of Jinju is very good if it is eaten with peel . . . Its fruits are used for preserving in syrup." As early as 1067, Ou Yang-xiu narrated an interesting history about *Fortunella* as commercial fruit, transported to the capital from South China: "The Jinju is produced in Jiangxi Province, it is difficult to ship to distant places. For this reason, it was virtually unknown to the people in the capital in the past. The Jinju was shipped to the capital (Kaifeng, Henan Province) together with bamboo for the first time during the beginning reign of Mingdao and Jingyou (1032-1034) . . . At first, the people did not pay attention to them. Afterwards, it had a sudden rise in its price because Queen Wencheng liked it very much" (3).

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According to early Chinese references about *Fortunella*, it was distributed in 6 provinces, i.e., Zhejiang, Sichuan, Guangdong, Jiangxi, Hunan and Jiangsu.

Some species and cultivars in *Fortunella* were already described in detail by Han Yan-zhi (1178) and Li Shizhen (1578).

The first reference on the use of trifoliate orange as a rootstock for citrus fruits appeared in a statement about the propagation of kumquat. Kuang Pan (ca. 1502) stated in Bin Min Tu Zhan that trifoliate orange was used as a rootstock for kumquat and was grafted in spring and transplanted in autumn. Actually, Zhang Shi-nan, in his You Huan Ji Wen, published in the 13th century, gave an interesting account of transportation and sale of the young kumquat plants: "The Jinju is growing in several districts of Jiangxi Province . . . The dealer, in recent years, has carried the seedlings by ship for sale. One boat shipped more than one thousand trees which are only 2-3 chi (0.66-1.0 M) high with many fruits. The price of one plant with many fruits and developed root system costs only two or three cashes." On the basis of the above statement, a plant of 0.66-1.0 M high, bearing many fruits might be a grafted budling.

The kumquat remained virtually unknown to Europeans until it was introduced into Europe in 1846, but was introduced into Japan earlier. The 'Jindan' (*F. crassifolia*) was introduced to Japan during the period 1674-1711 (2, 4).

SPECIES AND CULTIVARS

The 6 known species originated in China: *Fortunella hindsii* Swing., the 'Shanjinjan,' is a shrub or a small tree with numerous thorns. The flowers are very small, or only about 1 cm in diam. Fruits are very small, 1.13 × 1.15 cm, elliptic-globose in form, with

3 segments. The seeds are small and polyembryonic.

1. *F. hindsii* var. *chintou* Swing., the 'Jindou' is a shrub or small tree like 'Shanjinjan,' but its fruits are sub-globose in form and have the normal diploid number of chromosomes that differs from those of 'Shanjinjan' (4x).

2. *F. polyandra* (Ridley) Tanaka, the 'Changyejingan,' is a thornless shrub, with leaves 10-15 cm long, fruits nearly globose and about 2 cm in diam., with 3-5 segments. The seeds are monoembryonic.

3. *F. margarita* Swing., the 'Luofu,' is a small tree with thornless branches. Flowers are small, 1.85 cm in diam. Fruits are obovate-ellipsoid, with 4-5 segments with persistent style in most fruits. The seeds are monoembryonic.

4. *F. japonica* Swing., the 'Luowen,' is a small tree, usually with thornless branches. Flowers are small, 1.9 cm in diam. Fruits are small, round in form, 2.3-2.45 cm, with 5-6 segments. The seeds are monoembryonic.

Two cultivars are planted, 'Daluowen' and 'Xiaoluowen.' The fruit of 'Daluowen' are larger than that of 'Xiaoluowen.' The peel of 'Daluowen' is smoother than that of 'Xiaoluowen.'

5. *F. crassifolia* Swing., the 'Jindan,' is a small tree with few spines or spineless. The fruits are larger than those of other kumquats, 2.3-3.3 × 2.3-3.2 cm in size, with 6-7 segments. The seeds are polyembryonic.

It is the best species for fresh fruits and is widely grown in China. The 'Jindan' can be separated into several cultivars. Fruits of 'Dajindan' are relatively larger and ellipsoidal in form. Fruits of 'Xiaojindan' are smaller and round or subglobose in form. Some seedless varieties have been selected in China. Swingle (1915) originally considered 'Jindan' to be a species but later he suggested that it might be a garden hybrid derived from a cross of 'Luofu' and 'Luowen' or a backcross

of *Fortunella* with a *Citrus-Fortunella* hybrid (4). It is difficult to recognize that 'Jindan' is a biogeneric hybrid, because it possesses the typical characteristics of genus *Fortunella*. *F. crassifolia* differs, also, from *J. japonica* and *F. margarita* in a number of morphological characters such as thickened and broader leaves, thickened peels, more segments and polyembryonic seeds. It was found that the pollen morphology of *F. crassifolia* differs from that of *F. margarita* and *F. japonica* (6). It should be recognized as an independent species.

6. *F. obovata* Tanaka, the 'Changshoujingan,' is a shrub with thornless branches. The fruits are the largest ones among all species of *Fortunella*, 3.8 × 3.5 cm in size, obovoid in form but broadest at the apical part, segments 6-8. The seeds are polyembryonic. It was described as a species by Tanaka in 1933, but was not accepted by Swingle, who considered it a garden hybrid of 2 *Fortunella* cultivars.

Undoubtedly, China is the original center of *Fortunella*. It appears that the original distribution of *Fortunella* was limited to south of 30°N in China. All species are distributed in the subtropical area except *F. polyandra*, which is distributed in the tropical area such as Hainan Island of Guangdong Province. *F. hindsii*, a primitive species of *Fortunella*, still grows in a truly wild state in southeastern China, including Zhejiang, Jiangxi, Fujian, Hunan, and Guangdong provinces. The wild trees have been found in Fujian and Guangdong, most commonly growing in red loam at an elevation of 200-390 M above sea level. At present, the most important kumquat-producing areas are Ningbo, Zhenhai of Zhejiang, Yunxiao of Fujian; Liuyang, Lanshan of Hunan; Suichuan of Jiangxi; Rongan, Yangshuo of Guangxi. The commercially cultivated species

are *F. crassifolia*, *F. margarita* and *F. japonica*.

UTILIZATION

Kumquat is utilized primarily for fresh fruits and for candied fruits. It also has been used as a potted ornamental plant. Although the cultivars of *Fortunella* are few, it is important for genetic improvement of citrus fruits. Kumquat has many desirable characteristics, such as cold hardiness, interfertility, hybrid fertility, as well as the presence of monoembryonic seeds.

The trifoliate orange is widely used as a rootstock for kumquat in China. *Citrus grandis* and *C. medica* are sometimes used as rootstocks also.

Close planting with dwarf trees is an important practice for producing more fruits per unit area. The kumquat has been used as a dwarfing stock for *Citrus*. Wan Liang-cai et al. (5) used both 'Jindao' (*F. hindsii* var. *chintou*) and *C. limonia* rootstocks budded with 'Pongan' (*C. reticulata*). Three years after planting, the most dwarfed tree and highest yield were observed in the 'Jindao' rootstock combination. The average tree height of 'Pongan' grafted on 'Jindao' was 94.3 cm, whereas those on *C. limonia* stock was 135.0 cm. The average yield per tree on 'Jindao' stock in the third year after planting was 3.85 kg, whereas the yield on *C. limonia* stock was only 1.23 kg. Analysis of the fruits indicated that 'Jindao' stock slightly increased the percentage of total soluble solids, and its total soluble solids/acid ratio was decreased (13.03) (5). However, it is undesirable to use kumquat directly for rootstocks in commercial planting, because some characters of kumquat are not satisfactory for nursery practices, such as low seed content, low germinating ability, and monoembryonic seed in some cultivars.

Literature Cited

1. Huang Chenggui. 1959. A preliminary study of rue plants in China (Part Three). *Journal of Botanical Classification (Zhiwu fenlei xueboa)*, 8(1):69-124.
2. Hume, H. H. 1957. *Citrus Fruits*. pp. 90-95. The MacMillan Co.
3. Ye Jingyuan. 1960. Selected Works from Chinese Agricultural Science Heritage—Citrus. pp. 26-35, 71-82. Agricultural Publishing House.
4. Swingle, W. T. 1967. The Botany of Citrus and Its Wild Relatives. pp. 190-430 in *The Citrus Industry* (Rev. Reece, P. C., 1967).
5. Wan Chairong and others. 1980. A preliminary report on the experiment of short-stalked citrus. *Chinese Citrus (Zhongguo ganju)*, 1980 (4):6-9.
6. Ye Yinmin. 1981. A study on citrus pollen pattern. *Chinese Agricultural Science (Zhongguo nongye kexue)* (5):62-66.

Citrus Clonal Selection, Progeny Testing and In Vitro Propagation

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China is a citrus genome "reservoir" of the world. The history of citriculture has been recorded over 4,000 years, with abundant cultivar resources. Excavations dating back over 2,500 years ago, revealed citrus seeds and rind of *Citrus junos*. Han Yien-chih wrote the first citrus monograph "Chu Loh" dating back to 1178, recorded 27 superior cultivars in Zhejiang Province. Numerous original citrus species were found in southern provinces such as *C. honghoensis* YL DL, *C. medica miliensis* WYD, *C. ichangensis* Swingle, *C. junos* Sieb. ex Tanaka, and *Fortunella hindsii* Swingle.

There are three groups of citrus cultivars widely grown in China, i.e. *C. reticulata* Blanco, *C. sinensis* (L.) Osbeck, and *C. grandis* Osbeck. Owing to the frequent natural crossing and the phenomenon of nucellar embryony, numerous new cultivars and mutant were constantly formed. Recent clonal selection work revealed many nucellar mutants, but sports and chimera mutations. In clonal selection studies, it was shown that there are frequent bud mutations found in the vegetative shoots sprouted from the

parenchymatous regenerations. This phenomenon was also observed in callus culture of the diploid cultivars which developed tetraploids, triploids and haploids. This indicated that the mechanism of citrus mutation originated from the inner parenchymatous cell layers.

Methods of citrus clonal selection were carried out in Huazhong Agricultural College according to the following procedures; determining the objectives of clonal selection, discussing the technical standards, selecting clonal lines, laboratory quality analysis, progeny testing of clonal selections, and propagation of the superior mutants. Technical quality standards for oranges, mandarins, 'Ponkan' and tangerines were discussed. Using *C. unshiu* as interstocks for topworking for all clonal cultivars proved compatible. The complete procedures for progeny test, selection, topworking and registration for distribution can shorten the clonal selection program to about 3 years. This technique is also used for testing nucellar selections and hybrid progenies.

In vitro propagation of citrus clonal selections was conducted by two tis-

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