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Citrus Production and the Occurrence of Virus Diseases in the Mainland of China

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ABSTRACT. Although citrus is grown in 17 provinces in China, 97% of the production is concentrated in eight provinces. Production rose from 400,000 metric tons (MT) before 1978 to 5 to 6 million MT in the early 1990s as a result of an increase in area planted. Mandarins and sweet oranges constitute most of the plantings, but, in recent years, pummelo production has increased markedly. Most of the fruit is consumed locally as fresh fruit. The main graft-transmissible diseases recorded in China are huanglongbing, exocortis, tatter leaf, tristeza, satsuma dwarf and vein enation. Virus-free propagation projects are now operating in some major citrus producing provinces.

Citrus is one of the most important fruit crops in the mainland of China. Its production in recent years is second only to apple among all of the fruits. This report updates earlier reviews (4, 8, 11).

PRODUCTION AND DISTRIBUTION

Citrus production has risen significantly since the late 1970s. The area planted to citrus has increased from 168,000 ha in 1975 to 1,141,000 ha in 1990. Annual production of citrus never exceeded 400,000 metric tons (MT) before 1978, whereas it reached 5 to 6 million MT in the early 1990s. In 1994, production rose to 6.8 million MT. In recent years, however, the rapid development of citrus cultivation has stopped in most areas, and in some localities the acreage of citrus has declined.

Citrus cultivation occurs in 17 provinces and municipalities, with 97% of the total production found in the following eight provinces: Guangdong, Sichuan, Zhejiang, Hunan, Fujian, Guangxi, Hubei, and Jiangxi. The provincial production in Guangdong, Sichuan and Zhejiang exceeded 1 million MT in 1993.

Because of relative low temperatures, most areas in Zhejiang, Hunan, Hubei, and Jiangxi are not suitable for sweet orange, and only satsuma and some other mandarins

are cultivated. In the 1970s, mandarin plantings occupied 70% of the total, sweet orange 25%, and other citrus the remaining 5%. Among this last group, pummelo was predominant, with small amounts of kumquats and lemons. In the 1980s, sweet orange and pummelo plantings expanded more rapidly than mandarin and other types, and, by the early 1990s, the constitution had shifted to 50% mandarins, 42% sweet oranges, and 8% pummelos and other types.

Most citrus is consumed as fresh fruit in the domestic market. About 600,000 MT of citrus fruit are processed for juice and segment canning, and 50,000 to 100,000 MT of fruit are exported to Russia, other East European countries, Hong Kong, Malaysia, Singapore, and Canada.

The picking season of most citrus is from in mid-November to late December. Some of the crop might be stored for several months before sale. Ventilated storage houses are the most common facility for citrus storage, but air-raid shelters, cellars, and common houses are also used.

CULTIVARS AND ROOTSTOCKS

Satsuma is the most common mandarin planted. In the 1970s, Owari satsuma occupied more than 90% of the total satsuma area. Later,

more attention was paid to the development of early satsumas and, as a result, Okitsu, Miyagawa, and Kamei became predominant in new plantings. Some extra-early satsumas such as Wakiyama, Shebon, and Long-hui have also been selected and developed. Ponkan is also widely planted. It developed more rapidly than other mandarins in some provinces in the 1980s. Tankan is a traditional cultivar in south China, and is still important. Tangerines, including Hongju and Fujju, are important in Sichuan and Fujian respectively, while Bendi-zhao, Nan-feng-mi-ju and Cha-zhigan are famous local mandarin cultivars in Zhejiang, Jiangxi, and Guangdong, respectively.

Native common sweet orange constitutes most of the sweet orange plantings. Jincheng is predominant in Sichuan and Hubei, An-liu-cheng, Xin-hui-cheng, Gai-liang-cheng, and Xuegan are common in south China. Bing-tang-cheng is a famous cultivar in Hunan. Robertson navel, Washington navel, and Valencia orange were introduced into China from the United States in the 1940s and have been well developed in several counties. Ruby blood orange has also been introduced and developed, but to a lesser extent. Since the late 1970s, Newhall, Navelina, and other navel oranges have been introduced from the United States and Spain, and after trials, some of them have been developed to a large extent.

Famous cultivars of pummelo are grown in different localities, including Sha-tian-you, Guan-xi-mi-you, Yu-huan-you, etc. Among these cultivars, Sha-tian-you is most common. Commercial planting of lemons, mainly Eureka, exist in some counties of Sichuan. Kumquats are grown in Zhejiang, Jiangxi, Guangxi, and Hunan. Luofu (*Fortunella margarita*), Jindan (*F. crasi-folia*) and Luowen (*F. japonica*) are commonly cultivated.

Superior budlines of most cultivars, especially sweet oranges and

mandarins, have been selected and developed by horticulturists.

With regard to rootstocks, nearly all of the satsuma and kumquat are grafted onto trifoliolate orange. Pummelo is grafted onto pummelo; Eureka lemon, in general, is grafted onto tangerine. For sweet orange and mandarin (except satsuma), various rootstocks are used in different localities. In Guangdong, Guangxi and Fujian, Suanju (*Citrus sunki*), Hongli-meng (*C. limonia*), Tu-li-meng (*C. lomonia*) and San-hu-hong-ju (*C. erythrosa*) are commonly used, and, in some areas, trifoliolate orange is also used. In Sichuan and Hubei, trifoliolate orange is the main rootstock, while Hongju (*C. tangerina*) are used. In Hunan and Jiangxi, trifoliolate orange is the main rootstock, while Hongju (*C. tangerina*) and Zhuju (*C. erythrosa*) are also used in some areas. In Zhejiang, Gou-tou-cheng (probably a natural hybrid of sour orange) is important, and trifoliolate orange and Zhuluan (another probable hybrid of sour orange) are also used.

NURSERY AND ORCHARD PRACTICES

Most budlings are produced in the field, while a small quantity are produced in containers. In recent years, a type of cement bed has been developed for citrus propagation to improve phytosanitary conditions.

Citrus propagation is carried out by grafting in general. Grafting is usually conducted from August to October by side grafting with a single bud. In south China, grafting is also conducted in February and March by cut-grafting with a single bud.

Most citrus orchards are established on hilly land, and also on alluvium or other flat paddy fields. On hilly lands, terraces are usually made and planting holes or ditches are dug to a depth of 60-100 cm into which a mixture of soil, green manure, animal dung and other fertilizers is put to improve the soil condition before planting.

The general spacing of sweet orange and mandarin orchards is 3.3 × 4 m (about 750 trees/ha). Since the 1970s, close planting (about 1500 trees/ha) has been practiced in many localities, with the idea that half of the trees would be moved when crowding occurs. In the citrus orchards established on paddy fields with a high water table, the general spacing is 2 × 3 m (1665 trees/ha). The spacing for pummelo orchards is generally 5 × 7 m.

Other than organic materials, nitrogen and phosphorus fertilizers are widely used, while potassium fertilizer is used in some of the orchards.

Irrigation is carried out by making furrows or using movable pipes. Spray irrigation or drip irrigation is found in a few orchards.

Herbicides have been used in some orchards, but most weed control is by hand. Pruning is practiced by hand clipper.

VIRUS AND VIRUS-LIKE DISEASES AND OTHER PROBLEMS

The occurrence of huanglongbing (7, 12, 13), tristeza (2, 5, 13), exocortis (3, 13, 14), tatter leaf (6, 9, 10, 13, 15), satsuma dwarf (16) and vein enation (1) have been experimentally confirmed in different areas.

Huanglongbing is prevalent in the southern citrus area, including Guangdong, Fujian, Guangxi, the southern of Jiangxi, parts of Yunnan and Guizhou, and a limited area in the south of Zhejiang, Sichuan and Hunan. The practice on some large citrus farms of planting huanglongbing-free budlings, together with strict psylla control and timely discarding of diseased trees, can effectively check prevalence of huanglongbing.

Exocortis is common in some native sweet oranges, such as An-liu-cheng and Xin-hui-cheng, and has been found to a lesser extent in Xuegan, Bing-tang-cheng and Jincheng. It has not been found in

native mandarins, satsumas, pummelos and kumquats, except in a few cases. The introduced cultivars of Robertson navel orange and Eureka lemon are widely infected, while Washington navel and Valencia orange are infected to a lesser extent. The more recent introductions are generally free of exocortis.

Biological indexing showed that tatter leaf infected some of the trees of important native cultivars in Zhejiang, Guangdong, Fujian, and Hunan. Most important cultivars planted in Guangxi were introduced from Guangdong, and are, therefore, also infected. On the other hand, important cultivars native to Sichuan and Hubei are, in general, tatter leaf-free.

Tristeza is also widely distributed, but since the rootstocks commonly used are tolerant, damage caused by tristeza is not apparent. Following the expansion of pummelo cultivation in the 1980s, a dwarfing problem of pummelo was observed in some counties of Sichuan and Zhejiang. Leaf curling and severe stem-pitting are associated with the dwarfing. Biological indexing and ELISA revealed that pummelo dwarfing is caused by tristeza. Moreover, small fruits of sweet orange associated with stem-pitting, could be found in some localities.

Satsuma dwarf has been found in a few samples of satsuma which were introduced from Japan in the 1980s (16).

Vein enation has been found in some cultivars in Huangyan, Zhejiang province (1).

Huanglongbing was defined as a plant quarantine target in the late 1950s. Huanglongbing-free nurseries or mother blocks were established in Guangdong, Fujian and Guangxi on the basis of thermotherapy and/or tetracycline treatment in the 1970s and 1980s. Biological indexing and shoot-tip grafting (STG) have been practiced in several provinces since the early 1980s, and the established mother block was

supplemented with disease-free material obtained by indexing and STG. A virus-free propagation project in Sichuan and Hunan commenced in the mid 1980s using superior citrus varieties which had undergone indexing and shoot tip grafting. The legislative management for virus-free citrus propagation and the establishment of a countrywide virus-free citrus propagation center have been proposed.

Apart from virus problems in some of the citrus orchards, low yields of citrus is attributed to insufficient fertilization, especially organic

materials, lack of irrigation systems, and inadequate pest control.

Serious cold damage occurring in Zhejiang, Jiangxi, Hunan, and Hubei about once every 8 yr, and the sudden rise of temperature to more than 35°C in May cause heavy fruit drop in some provinces are important factors which check the expansion of citrus production.

Attempts to develop cultivars to prolong the picking season, and the development of the processing of more fruit should be encouraged in the future.

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