U.S.-China Citrus Symposium

C. Jack Hearn

A United States-People's Republic of China Citrus Symposium was held in Orlando, Florida, November 14-17, 1983. It was jointly sponsored by the United States Department of Agriculture, Office of International Cooperation and Development and the Agricultural Research Service and the Chinese Ministry of Agriculture, Animal Husbandry and Fishery.

The original purpose of the meeting was to report on collection, preservation and utilization of citrus germplasm. Later, the program was expanded to include production and post harvest research topics. A discussion session on germplasm availability, preservation and exchange was held and germplasm has been exchanged since the symposium.

The papers presented at the symposium were edited by C. Jack Hearn, of the Agricultural Research Service, Orlando, Florida.

Citrus Production and Research in China

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China is one of the most important native lands of citrus. Several citrus species are found in the wild state at present. Commercial cultivation of citrus has been recorded in China for more than 2,500 years. Citrus plantings are distributed in 18 of the 30 provinces and metropolitan areas in the country. The important production areas are located in the provinces of Sichuan, Guangdong, Zhejiang, Guangxi, Hunan, Fujian, Hubei, Jiangxi and Taiwan. Excluding Taiwan, the total area of citrus was 260,000 hectares producing 710,000 tons in 1980. The citrus production of 1981 and 1982 was 798,000 tons and 939,000 tons, respectively. Most citrus fruits are consumed fresh in the domestic market, and a small portion is for the processing of canned segments and orange juice, for export.

Since about one-half of the citrus orchards are nonbearing at present, the relatively rapid development of the production of citrus in the near future is predicted.

Producing regions. Citrus-producing regions are located from 18 to 37° north latitude. The annual mean air temperatures are 14.5° to 27°C, the extreme minimum air temperatures are −9° to 0°C, and the annual precipitation is generally about 1,000 mm, with the most rainfall in spring and summer. The important citrus-producing region has been subdivided to three districts based on the climatic adaptability.

Northern subtropical producing districts. The annual mean air temperature is 15° to 17°C, with rainfall of 750 to 1,000 mm, the extreme minimum air temperature is commonly

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about −5°C. This district includes most of the provinces in Hubei, Hunan, Jiangxi, Zhejiang, Jiangsu, Guizhou, etc. Mandarin is the main citrus crop in this district.

Middle subtropical producing districts. The annual mean air temperatures is 18° to 22°C, the extreme minimum air temperature is −2° to −3°C, and the rainfall about 1,000 mm. This district comprises the Sichuan Basin, the Gorge region of Yangtze River, the southern part of the provinces of Zhejiang, Hunan and Jiangxi, western part of Hubei, and the middle part of the provinces of Fujian, Guangdong and Guangxi. Mandarin and sweet orange are the main citrus types in this district, and shaddock is also produced.

Southern subtropical producing districts. The annual mean air temperature is 22° to 24°C, the annual precipitation is 1,200 to 2,000 mm, and snow and frost are rare. This district includes most of Taiwan Province, the southern part of the provinces of Fujian, Guangdong, Guangxi, and the Xishuangbanna region of Yunnan Province, etc. The main citrus types are mandarin and sweet orange, and shaddock is also important.

Citrus scion cultivars. Mandarins are leading in hectareage and yield in Chinese citriculture. Satsuma (*Citrus unshiu* Marc.) is planted mainly in northern and middle subtropical citrus districts. The planting of satsuma expanded more rapidly than that of other cultivars in the 1960's, and has replaced 'Tankan' (*C. tankan* Tan.) as the main cultivar of mandarin in China. 'Tankan' is commercially cultivated in the southern subtropical citrus district. 'Tankan' is valued for its high productivity, late ripening (picked in January-February) and good performance in storage. 'Ponkan' (*C. reticulata* Blanco), the most promising cultivar of mandarin, is widely planted in Fujian, Taiwan, Guangdong, and Guanxi, and is also planted on a small scale in Zhejiang, Sichuan, Hunan and Hubei. 'Hongju' (*C. tangerina* Hort. ex Tan.) is known for high yield and good appearance and is important in Sichuan and Fujian provinces. 'Zhuju' (*C. erythrosa* Hort, ex Tan.), an ancient cold-hardy cultivar is historically planted as a dominant cultivar in the most northern citrus areas. 'Zhuju' has been replaced by satsuma in the recent plantings. The small-fruit-type mandarin, 'Nanfengmiju' (*C. kinokoni* Hort. ex Tan.) and 'Bendizau' (*C. succosa* Hort. ex Tan.), are the local cultivars of Jiangxi and Zhejiang, and are widely planted in Nanfeng and Fuzhou of Jiangxi and in Huangyan of Zhejiang, respectively.

Sweet orange (*C. sinensis* (L.) Osb.) is second in hectarage and yield in the Chinese citrus industry. Zianfengcheng and Jincheng are predominant cultivars in Sichuan and Hubei. The trees grow vigorously with high productivity, the fruit has a good flavor and is juicy, and also has a long storage life. 'Xuegan' is one of the important cultivars in Fujian, and performs similarly to 'Jincheng.' 'Xinhuicheng' and 'Liucheng' are acidless cultivars widely grown in Guangdong, Guangxi and Taiwan. Navel orange, 'Valencia' and 'Ruby Blood' are grown in many locations. Navel and 'Valencia' have been commercially planted in some localities in recent years. 'Hamlin' was introduced from Morocco in the 1960s, and is performing well in several districts. The planting of 'Hamlin' has increased in recent years.

'Shatianyou' shadock (*C. grandis* (L.) Osbeck) is an acidless cultivar with commercial plantings in Guangxi and Sichuan. Both 'Wanbaiyou' and 'Madouwendan' are cultivated mostly in Taiwan. Famous local cultivars in their native provinces are 'Wendan' of Fujian, 'Liangpinyou' and 'Kuifuhongxinyou' of Sichuan, and 'Sijipao' of Zhejiang.

Citron (*Citrus medica* L.) and fingered citron (*C. medica var. sarcodactylis* (Noot.) Swingle) have scattered distribution in the middle and southern subtropical citrus districts. The citron is mainly used for medicinal and ornamental purposes.

'Eureka' and 'Lisbon' cultivars of lemon (*C. limon* (L.) Burm. f.) are planted in a limited area in Sichuan.

Sour orange (*C. aurantium* L.), 'Daidai' is planted in Fuzhou, Fujian, and is protectively planted in Suzhou, Jiangsu. The flower of 'Daidai' is used for scenting tea.

'Loufu' (*Fortunella margarita* (Lour.) Swingle), 'Louwen' (*F. japonica* (Thumb.) Swingle) and 'Jindan' (*F. crassifolia* Swingle) are consumed as fresh or preserved fruits, and are used as ornamentals, also. The main producing area of kumquat lies to Ningbo and Zhenhai counties of Zhejiang, Yunxiao county of Fujian, Suichuan county of Jiangxi, Liuyang and Lanshan counties of Hunan, and Rongan and Yangshuo counties of Guangxi.

Trifoliate orange (*Poncirus trifoliata* (L.) Raf.) is an important rootstock in Chinese citriculture, and its fruit can be used for medicinal purposes. The distribution of trifoliate orange is mainly along the Yangtze River Valley.

Rootstocks. Trifoliate orange is used as rootstock for nearly all the satsumas and kumquats in various citrus areas, and also for other mandarins and sweet oranges in the middle and northern citrus-producing regions.

Suanju (*C. sunki* Hort. ex Tan.), Limong (*C. limonia* Osbeck). Hongju (*C. tangerina* Hort. ex Tan.) and some other mandarins are used for sweet oranges and mandarins in the southern citrus-producing region, and in some cases Hongju is also used in other regions. Since the 1950's, Sanhuhongju (*C. erythrosa* Hort. ex Tan.) has been used as rootstock by certain orchards in Guangdong with good results.

Goutoucheng (*C. aurantium* L.) is used as the main rootstock in the coastal region of Zhejiang to adapt the citrus plantings to the saline-alkali soils.

Shaddock is graft propagated on its own roots.

Propagation methods. Grafting is widely used in citrus propagation, although layering and seedling trees are still used in some cases. The single-bud grafting in spring, and the single-bud side grafting and shield budding in autumn and spring are practiced. In general, 3 years are needed to produce a grafted nursery tree for planting.

Orchard practices. The citrus orchards are established on hills, the hilly land with a gentle slope, the alluvial soil along the rivers, and other flats including the flatland with high water table where rice is usually planted.

The general spacing in citrus orchards is 3.3 × 4 m, i.e. about 750 trees/ha, and the spacing of 4 × 5 m is also practiced in some districts. In recent years, close planting has been practiced in some orchards with about 1500 trees/ha. One-half of the trees are removed after tree crowding occurs. The spacing in the flat land with high water table is 2.0-2.7 × 2.7-3.3 m.

On the hills, terraces are usually prepared before citrus planting. Soil improvement procedures are carried out before and after planting where the orchard tilling depth is not deep enough for root development. In that case, a cubic meter planting hole or a 1-m-wide and 1-m-deep planting ditch is prepared. In recent years, a 60-cm- rather than 1-m-deep planting hole or ditch is recommended in Guangdong and in some other districts. The planting hole or ditch is usually filled with soil mixed with pig or cow dung, green manure, and weeds or compost. In some orchards, cake, bone meal or calcium superphosphate and lime are

also mixed into soil to fill the planting hole or ditch. After planting, a ditch about 40 cm deep is dug around the tree canopy each year and organic fertilizers mixed with soil are used to fill the ditch. In the alluvial orchards, the depth of the planting hole or ditch is generally about 50 cm, and organic fertilizers are also used as mentioned above. In the flatland with high water tables, a mound is usually prepared for planting, and after planting, a ridge and ditch are prepared.

In addition to the organic fertilizers mentioned above, chemicals, such as urea and ammonium sulfate, are commonly used. In some orchards, especially in the flat orchards with high water table, liquid fertilizer mixed with cake, pig dung, etc., is applied. Six to 10 annual fertilizer applications in young orchards and 4 to 6 in bearing orchards are recommended. In certain orchards, urea spray for foliar nutrition is practiced.

Flat orchards with a high water table are irrigated at intervals. The water usually stays in the ditch for a period of time so as to allow permeation through the ridge. In the orchards on hilly land and of other flatland, furrow irrigation is carried out in the dry season when slight leaf wilt occurs. Sprinkling or drip irrigation is available in a limited number of orchards.

In general, dead twigs are pruned off and the water sprouts are cut back every year. In some districts, the thinning and cut back of the bearing shoots are also performed after harvest. In the orchards with good care, occasional summer sprouts and autumn shoots of young trees are pinched off when the shoots are about 1 cm in length, to induce uniform sprouting of summer shoots and autumn growth. As for the trees at the initial bearing stage, all of the summer sprouts are pinched off to reduce fruit drop and to induce uniform autumn sprouting.

Diseases, insect and mite pests and cold injury. Huanglongbing (citrus yellow shoot disease) which prevails in southern citrus-producing areas is the most serious problem in the Chinese citrus industry. Citrus canker, scab, foot rot, exocortis, black spot (*Guignardia citricarpa* Kiely) and anthracnose may cause damage in many citrus areas. Red mite, rust mite, arrow head scale, red wax scale, leaf roller, leaf minor and sucking moth are widely distributed and may cause serious damage. The citrus orchards are generally protected with insecticides and miticides with 4 to 10 annual sprays. Periodic cold injury occurs in northern citrus-producing areas and causes serious damage there.

Citrus Research

The institutes involved in citrus research were established successively in the provinces where citrus trees are commercially planted. Among these Zhejiang Citrus Research Institute, Sichuan Fruit Research Institute and Shantou Citrus Research Institute of Guangdong have been established longer than the others.

The Citrus Research Institute of the Chinese Academy of Agricultural Sciences was established in Chongqing, Sichuan in 1960, and the cultivar collections of the country are located there.

Citrus research is also conducted in the agricultural colleges. The Citrus Research Laboratory of Huazhong Agricultural College was established by the Ministry of Agriculture, Animal Husbandry and Fishery in 1979.

Moreover, some institutes of the Chinese Academy of Sciences, such as Shanghai Biochemistry Research Institute, Guangdong Insect Research Institute are also engaged in citrus research.

Cultivar research. The basic work, such as the collection and research of the wild and cultivated citrus resources and the establishment of the variety collections, has been conduct-

ed in the provinces where citrus is an important crop. The selection of bud mutations has been conducted in all citrus-producing provinces. Hybridization work began in the 1950's. Since the 1960's, in addition to hybridization, induction of mutation by physical and chemical methods has been carried out. In recent years, triploid and monoploid plantlets have been obtained by tissue culture from the endosperm and anthers, respectively. In addition to the above-mentioned selection and breeding work, studies of citrus isoenzymes by electrophoresis, the physiological and biochemical indices of cold tolerance and the pollen morphology of different citrus species and cultivars by SEM are conducted in some laboratories.

Research on cultural practices. Studies are carried out on overcoming alternate bearing, soil improvement of citrus orchards, the effect of green manure and chemical fertilizers in citrus groves, tree spacing, and the prevention of fruit drop by using plant growth regulators. Pruning techniques to increase fruit production have also been studied.

Research on citrus diseases and pests. Research emphasis is on the pathogenicity, the vector and the control of Huanglongbing. Studies on the epidemiology and control of citrus canker, scab, black spot, etc., and on the cause and control of satsuma sudden wilt have been conducted. The exclusion of virus and virus-like pathogens from citrus by shoot-tip grafting has been started in recent years. In pest research, the biology, the population dynamics, and chemical and biological control procedure of red mite, rust mite, arrowhead scale, red wax scale, leaf roller, leaf minor, etc. are studied.

Research in fruit storage. Since most citrus fruit are picked in November through December, storage of this fruit is practiced to extend the period of market supplies. Studies on the storage techniques, including the seal-package of the fruit with polyethylene film and the selection of chemicals used for the control of fruit rot, are carried out.

Some achievements in the above-mentioned research work will be described in this symposium.

Wilder Certificates Awarded

Roy C. Rom

At the annual meeting of the American Pomological Society held August 6, 1984 a seldom awarded Wilder Certificate of Recognition was presented to Drs. Jules Janick and James Moore. The awards were made in recognition of their significant contribution to Horticulture in publishing the two comprehensive volumes on the breeding of temperate and tropical fruits. *Advances in Fruit Breeding* is a 640 page text consisting of 20 chapters authored by 27 specialists in fruit breeding. *Methods in Fruit Breeding* is a new look at fruit breeding and it considers the subject from a procedural and theoretical point of view. This volume has 24 chapters compiled by 32 specialists.

The American Pomological Society was delighted to honor Dr. Janick and Moore for their foresight and perseverence in editing these most important volumes. Dr. Jules Janick is Professor of Horticulture at Purdue University and Dr. Moore is Professor of Horticulture and Forestry at the University of Arkansas.