

CHINESE-AMERICAN
JOINT COMMISSION ON RURAL RECONSTRUCTION

Plant Industry Series: No. 1

CITRUS CULTURE IN TAIWAN

By
LUH, Chi-Lin



Taipei, Taiwan, China
First Edition: September 1953
Second Edition: June 1956
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Citrus Culture In Taiwan China

A. A Historical Review of Citriculture in China

According to Prof. C. C. Hu's study⁵, citrus growing in China began as early as 2,200 B. C. during the Sha (夏) and Shang (商) Dynasties. Also presented in Hu's same study, the small loose-skinned oranges were the earliest citrus fruits grown in China some four thousand years ago, with Hsiang Chen (香橙) (*Citrus junos*) and Trifoliate orange (枳殼) (*Poncirus trifoliata*) assuming the predominance. The citrus fruit which has been cultivated in China for more than three thousand years until the present is Pummelo (*Citrus grandis*); while those existing ones having a history of about two thousand years are sweet orange (*Citrus sinensis*), Mandarin (*Citrus deliciosa*), Tangerine (*Citrus tangerina*) and Citron (*Citrus madica*). For the past one thousand years, Kumquat (*Fortunella margarita*), Lemon (*Citrus limon*) and Canton lemon (*Citrus limonia*) have been grown until the present days. Species introduced from abroad within past one hundred years are grapefruit (*Citrus paradisi*) and Lime (*Citrus aurantifolia*). Such historical notes may be tabulated as follows:

History of cultivation	Chinese common name	Chinese synonyms	Representative species		
			Scientific name	English name	Chinese name
Over 4,000 years	橘		<i>Citrus microcarpa</i>	Clamondin	四季橘, 公孫橘, 月橘
			<i>Citrus nobilis var. compressa</i>	Tsao chii	早橘
			<i>Citrus deliciosa</i>	Mandarine	橘
	香橙	橙子, 柚	<i>Citrus junos</i>	Hsiang Cheng	香橙
			枳	枳殼, 枳實	<i>Poncirus trifoliata</i>
Over 3,000 years	柚	文旦, 欖, 拋	<i>Citrus grandis</i>	Pummelo	柚
				Shaddock	

Over 2,000 years	橙	黃果，廣柑	<i>Citrus sinensis</i>	Sweet orange	甜橙
		酸橙	<i>Citrus aurantium</i>	Sour orange	酸橙
	柑	蜜柑	<i>Citrus poonensis</i>	Swatow orange or Ponkan	椪柑
		蜜橘	<i>Citrus tangerina</i>	Tangerine	紅橘
	枸橼	香橼	<i>Citrus medica</i>	Citron	枸橼
			<i>Citrus medica</i> var. <i>sarcodactylis</i>	Fingered citron	佛手柑
Over 1,000 years	金柑	金橘	<i>Fortunella</i> <i>crassifolia</i>	Chin Tan Kumquat	金彈
			<i>Fortunella</i> <i>margarita</i>	Lo Fu, Kumquat	羅浮
	檸檬	香檬	<i>Citrus limon</i>	Lemon	檸檬
	檸檬	廣東檸檬	<i>Citrus limonia</i>	Canton lemon or Rangpur	檸檬
			<i>Citrus paradisi</i>	Grapefruit	葡萄柚
Introduced within last 100 years	雷姆		<i>Citrus aurantifolia</i>	Lime	雷姆

B. Citrus Regions of China

The citrus growing areas in China may be grouped into three regions, namely, the southern—the most important region—including Hai-nan Island, Taiwan Island, and provinces of Kwangtung, Kwangsi, Yunnan and Fukien; the central region including Provinces of Kweichow, Kiangsi, Hunan, Szechuan, Sikang, Chekiang, Kiangsu, Anhwei and Hupei; and the northern region covering the province of Shensi.⁴

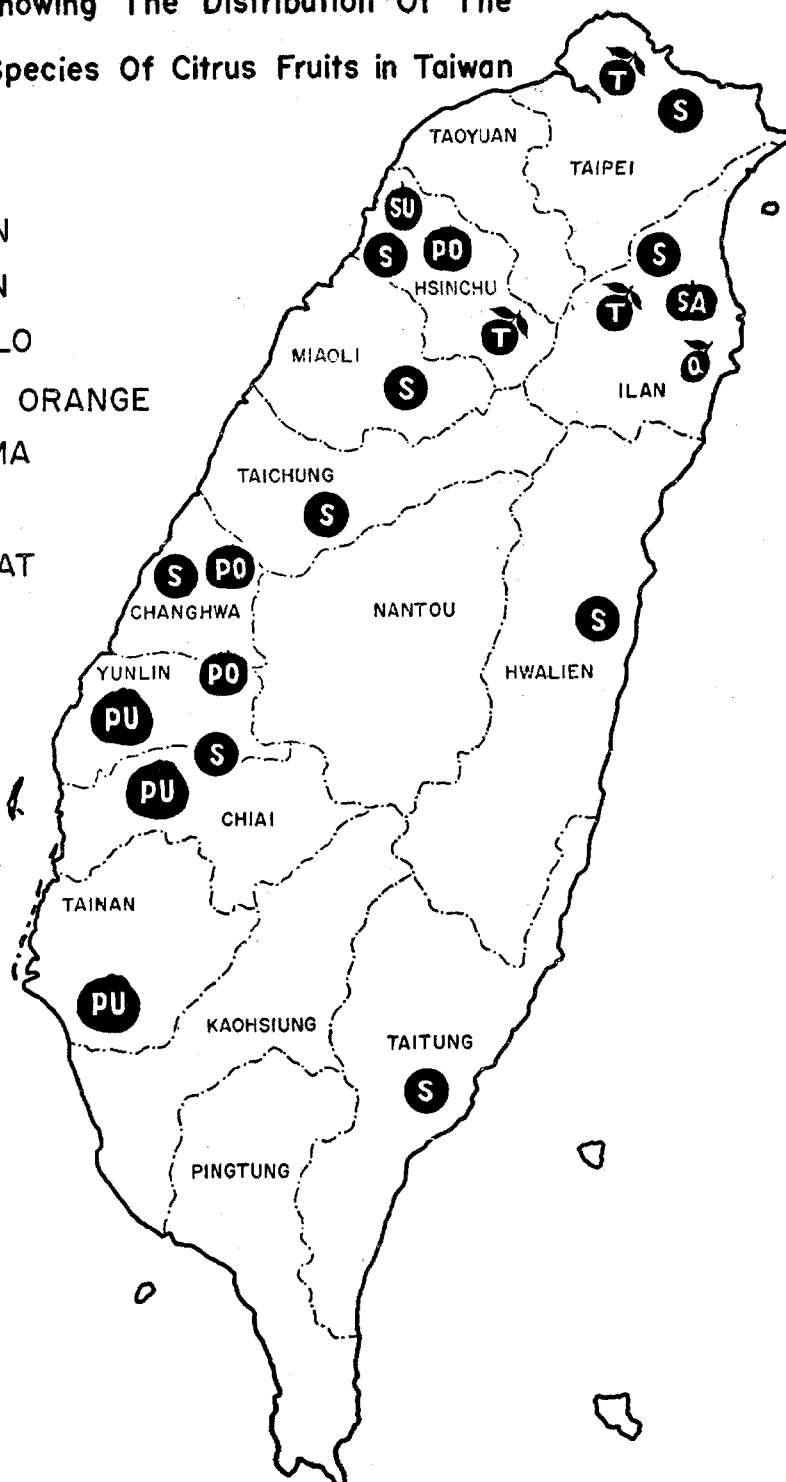
With regard to this topic, I would like to bring up some corrections on the statement contained in the article "Botanical and Historical Aspects of Asiatic Citriculture" written by Mr. Tyozaburo Tanaka and appeared in *Citrus Leaves*, March 1955 edition.⁶ Mr. Tanaka said, "The sweet orange, however, disappeared from the Yangtze Valley, probably because of climatological unsuitability or for some unknown reason, and now thrives only in the Canton region." In fact the sweet orange groves are not only found in places along upper Yangtze River in Szechuan but also there are several sweet orange producing centers in Szechuan on both sides of Yangtze River. Hwang-Kuo (黃果) is the local name for sweet orange in Szechuan. Kiang-Chin (江津), Nan-Ch'ung (南充) and King-Tang (金堂) are prefectures famous for sweet orange production in upper Yangtze Valley. Therefore, the geographic distribution of sweet orange in China is rather wide and, certainly not limited in the Canton region only.

C. Citrus Culture in Taiwan

According to the Taiwan Regional Annals (臺灣地方誌), citrus cultivation began first in central and southern Taiwan in 1664 (康熙三十三年) at the end of the 17th century when a large scale migration of people from the coastal areas of Fukien and Kwangtung Provinces of mainland China to Taiwan took place. Brought along with these migrants were various kinds of crop planting materials and incidentally several citrus species were included. Nursery-trees of Ponkan and Tonkan were being introduced to Taiwan from southern China even as late as 1930. However, large scale production was not developed until late 1920. At present, the economic value of citrus fruits ranks third among the fruit crops exported from Taiwan, only next to banana and pineapple.

Map Showing The Distribution Of The
Principal Species Of Citrus Fruits in Taiwan

- PO** PONKAN
- T** TONKAN
- PU** PUMMELO
- S** SWEET ORANGE
- SA** SATSUMA
- SU** SUNKI
- Q** KUMQUAT



D. Environmental Factors Favorable to a Sound Citrus Production in Taiwan

Ideal geographical location: Taiwan, the island province of the Republic of China, is located so closely to the important citrus producing areas in Fukien and Kwangtung Provinces on the mainland that numerous citrus species and varieties could be supplied from mainland China from time to time without much difficulty. At the same time, new planting materials may also be obtained from different parts of the world through ocean transportation; while the export of citrus fruits from Taiwan is also facilitated by such access.

Favorable climatic conditions endowed by the nature: The greatness of the Nature is truly beyond human imagination. The climatic conditions in each area limit the natural status of fauna and flora and the growing of citrus in any area of world is unexceptionally restricted by the climatic conditions. The island of Taiwan, well located in the citrus belt of the world, is endowed with most favorable climatic conditions. This phenomenon may be shown by the data as given below:

	Taipei	Taichung	Tainan	Taitung
Day length (hrs.) (41-year average)	1,920	—	2,950	—
Rainfall (mm.)	2,110	1,742	1,748	1,806
No. of rainy days	189.9	127.8	108.6	—
Temperature (°C)				
Mean maximum (July)	33.1	32.5	32.0	31.5
Mean minimum (Feb.)	11.9	11.5	12.6	15.5

It is obviously noted that freezing would not be a problem in growing citrus fruit in Taiwan since the low temperature rarely goes down to freezing point, thus requiring no heating process in citriculture. With an average rainfall of over 1,500 mm., the soil moisture would largely remain moistened and thus irrigation of citrus grove would not be critically needed as is the case in other citrus producing areas in the world. With a total

of nearly 2,000-3,000 hours of day length, an adequate heat supply for photosynthesis and fruit maturity would provide enough energy for obtaining a sizable crop. The only thing which draws the constant concern of every grower in Taiwan is the seasonal typhoon damage. In fact, any wind with an average velocity between 15-40 m. per second would usually blow away most of the nearly mature marketable fruits and cause serious damage to a young grove by rooting out the trees to cause immediate death of the trees.

E. Principal Species and Commercial Varieties under Cultivation in Taiwan

Some 30 species of citrus crops are either grown wide or under cultivation in different parts of Taiwan.¹⁷⁷⁸ The indigenous species are rather unimportant to the citrus production of Taiwan from both the cultural and economic points of view. The species commercially grown in Taiwan are as follows.

Ponkan (*Citrus poonensis* Hort): Classified as a variety of mandarin under *Citrus reticulata*, Ponkan is commonly called *Citrus poonensis* in Taiwan at present. It is reported to be native to Poona in India with a native name, Suntara. It has become a popular citrus fruit in southern China. The major Ponkan producing areas in Taiwan at present are Hsinchu, Taichung and Chiayi. Majority of the groves are located on slopelands with only a few on the lowland in Changhwa area.

Fruit globose or oblate with concave and ray formation apex; ridges on the calyx end; rind coarse with conspicuous oil-glands; loose and thin rind; segment 9-12; pulp deep orange with excellent flavor; juice sacs of delicious taste and desirable texture; seeds few to none; very poor keeping quality; and an early maturing citrus fruit in Taiwan.

Tonkan (*Citrus tankan* Hayata): Native to southern China, Tonkan is classified as a variety of sweet orange but is generally called *Citrus tankan* in Taiwan. Due to its fruitfulness, late maturity, good shipping quality and considerable degree of resistance to typhoon damage, Tonkan takes a leading position in acreage and production in Taiwan among other commercial citrus fruits. The most important production centers of Tonkan are all located in northern Taiwan, namely, Ilan, Taipei, Hsinchu and Miaoli.

Fruit globose to moderately depressed; smooth and thick rind in deep reddish orange color; rind not loose but slightly tight to segments, segments 9-11; pulp deep orange color, sweet with very low acidity. Fruits mature in late December through late March in Taiwan and have very good keeping quality when properly stored.

Sweet orange (*Citrus sinensis* Osbeck): Native in the Sikkim Mountains in India, the sweet orange was introduced to China in the days of Chinese Han Dynasty (1st Century).² In Chinese the name for sweet orange is "Cheng" (橙). Tien-cheng (甜橙) is a proper translation for sweet orange. The growing of sweet orange in China has had a long history and it is extensively grown in the southern and western parts of China proper and eastern and southern Taiwan at present.

Among the three groups of sweet orange as suggested by H. J. Webber (1949), i.e. the normal fruit group, the navel fruit group and blood fruit group, only the normal fruit group is of commercial value in Taiwan at present. The most important varieties under cultivation in Taiwan are Valencia late, Sikan, and Lue-Gim-Gong.

A medium variety, Sikan first originated in Ch'aochow (潮州) of Kwangtung Province. The cultivation of this variety was recorded as early as 1696. It is the most popular sweet orange variety in China.

Valencia, a late variety, was first brought into Taiwan in 1909 from Japan, then several introductions were made later in 1924 and 1956. It has a good adaptability in southern and eastern Taiwan.

Also a late variety, Leu-Gim-Gong was first introduced into Taiwan from Japan. The second introduction was made in 1953 by the author. Through top work, the planting of this variety is expanding in central and southern Taiwan.

In general fruits of the sweet orange group are globose or oblate in shape; rind smooth, light orange to golden yellow color, tight to segments; pulp rich in flavor and subacid; very good shipping and keeping quality. The maturity varies with varieties from medium to late.

Pummelo or Wen-Tan (*Citrus grandis* Osbeck): Pummelo (文旦, 柚) (shaddock), native of Indo-China, is a famous fruit of China and Thailand. The famous variety *Mato* Wentan of Taiwan was brought to Taiwan from Kwangtung by Huang Chuen (黃權) in Chin Dynasty in 1788 (清乾隆五十三年)¹. Now it is the most popular variety in Tainan area of southern Taiwan. Besides *Mato* Wentan, other important varieties of shaddock commercially grown are Pai-you (白柚) and Tou-you (斗柚). The variety *Pai-you* was brought to Taiwan from Fukien. Hsinchu is its production center. Late *Pai-you* was introduced from Malaya by a Japanese in 1920. *Tou-you* is the largest ball-shaped citrus fruit. There are many strains of different maturity and fruit quality. The important producing areas are on the west coasts of northern, central and southern Taiwan.

In general, fruits are very large, globose or pyriform, light lemon in color, rind very thick dotted with large oil glands; segments large, juice-vesicles large; pulp in light color; flavor acid and bitter taste; seeds numerous.

Satsuma or Wenchow mikan (*Citrus unshiu* Marcovitch): H. J. Webber grouped satsuma into a species called *Citrus reticulata* Blanco as a variety of Mandarin orange. But now *Citrus unshiu* is commonly used in the Orient. It is a chance seedling from Tsao-chieh (早橘) which originated in Wenchow and Hwanggai (黃巖), two places famous as citrus producing centers in Chekiang Province, China. It was brought into Japan in the days of Tang Dynasty (8th Century 德川時代) by Japanese monks who

learned Buddhism in Tien Tai Mountains (天臺山) near Hwanggai.³ Satsuma is the English name for Unshiu mikan as called by the Japanese.

The variety of seedless satsuma orange was shipped to Taiwan from Japan in 1910. Its present growing areas in Taiwan are Ilan, Miaoli and Hwalien. Although its acreage and production are limited as compared with other citrus fruits in Taiwan, it still has the value to be planted because of its earliness in maturity and good canning quality. The varietal characters consist generally of the following: fruit-medium sized, depressed globose, deep orange in color, rind coarse to smooth; segments 9-13; pith hollow, seedless, an early maturing Mandarin fruit.

Sunki (*Citrus sunki* Hort): The sunki species is native of Kwangtung and is generally grown in northern Taiwan, especially in Hsinchu area. Because of its beautiful and fibrous root system and seediness, sunki is purposely grown as a rootstock for Ponkan and Tankan at present in Taiwan.

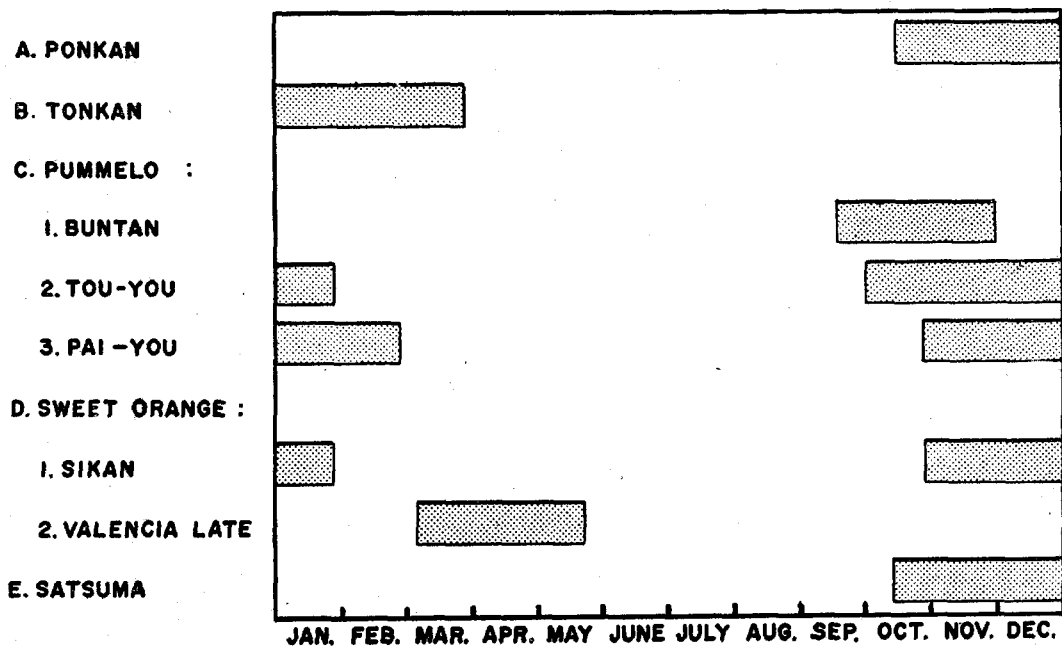
Sunki fruit is small in size and globose in shape; rind thin and loose; pulp strongly acid. Segments 7-10. The fruit matures in January and each fruit with a weight about 12-15 gm. contains 20-30 seeds.

Kumquat (*Fortunella* sp.): Native to China, a citrus fruit with several species, kumquat is grown for ornamental as well as for preservation purpose. *F. crassifolia* Swingle (Meiwa 金彈) is native of Chuanshan (穿山) of Chekiang. It was introduced into Japan in 1828. Fruit is oval in shape weighing about 10 gm. and with thick rind, suitable for processing. *F. obovata* Tanaka (長壽金柑) native of Fukien. Fruit oblong to oval, weight 35-40 gm. with thick rind.

Some Measurements of Major Citrus Fruits Grown in Taiwan

	Height	Width	Weight			Thick- ness of rind	% of flesh	No. of segments	No. of seeds
			Fruit	Rind	Flesh				
	cm.	cm.	gm.	gm.	gm.	cm.			
Satsuma	5.0	6.3	113	23	90	0.30	80	11	4
Ponkan	6.4	7.8	142	36	106	0.40	75	11	8
Tonkan	4.7	5.4	82	20	62	0.19	72	9	2
Sikan	6.1	6.2	133	29	104	0.22	77	11	4
Valencia late.	6.0	5.2	140	36	104	0.20	76	11	0
Mato Wentan	11.3	10.2	455	140	232	0.80	51	14	41
Pai-you	14.5	14.5	1,011	451	576	1.90	57	17	84
Sunki	2.8	3.8	19	5	14	0.30	72	10	11
Kumquat	4.0	2.8	18	8	10	0.3	55	5	2

Graph Showing The Seasonal Supply
Of Citrus Fruits In Taiwan



F. Topography, Sites and Soil of Citrus Groves in Taiwan

Citrus groves in Taiwan are located on both hillsides (usually below 500 m. above sea level) and on plains, with groves on the former type of land being far greater in number, larger in acreage and higher in productivity than those on the latter. In 1964 the acreage of all the groves on the plains (600 ha.) constitutes less than 5% of the total harvested acreage (13,361 ha.) of citrus plants.¹¹ The average size of a citrus grove on the plain rarely exceeds 0.3 ha.; however, a grove over 1 ha. in size is getting popular in recent years as a result of the land reform program implemented by the Government. When a grove is to be established on hillside or slope land, terrace and other soil and water conservation measures are carefully installed, regardless of the soil types.

Groves on the plains are located nearby the farmers' homesteads, while those on the slopeland and in the mountain areas are 0.5-1.0 km. away from the farm houses. Because of the destructive typhoons prevailing in the fall of each year, all the citrus groves located either on the hillside or on the plains in Taiwan are subject to typhoon damage. Hence planting of windbreaks is one of the most important practices in citriculture in Taiwan. Bamboo (*Bambusa* spp.) is extensively used as windbreaks for almost all the citrus groves existing on the Island. Except those on hillsides with gravels, the soils of citrus groves on the plains and hill foot in Taiwan are of the pleistocene (= ice age) alluvial type with acid to neutral reaction, and are suitable for growing citrus fruit trees. Volcanic soils are also found in the mountainous groves in Yangmingshan area of northern Taiwan. Red soil rich in iron is a typical soil for citrus groves in Hsinchu area. Gravelly riverbeds on the east coast in Taitung Prefecture area are also utilized for growing sweet oranges. The soils for citrus trees in Taiwan have a wide variation in nurturing different kinds of citrus crops.

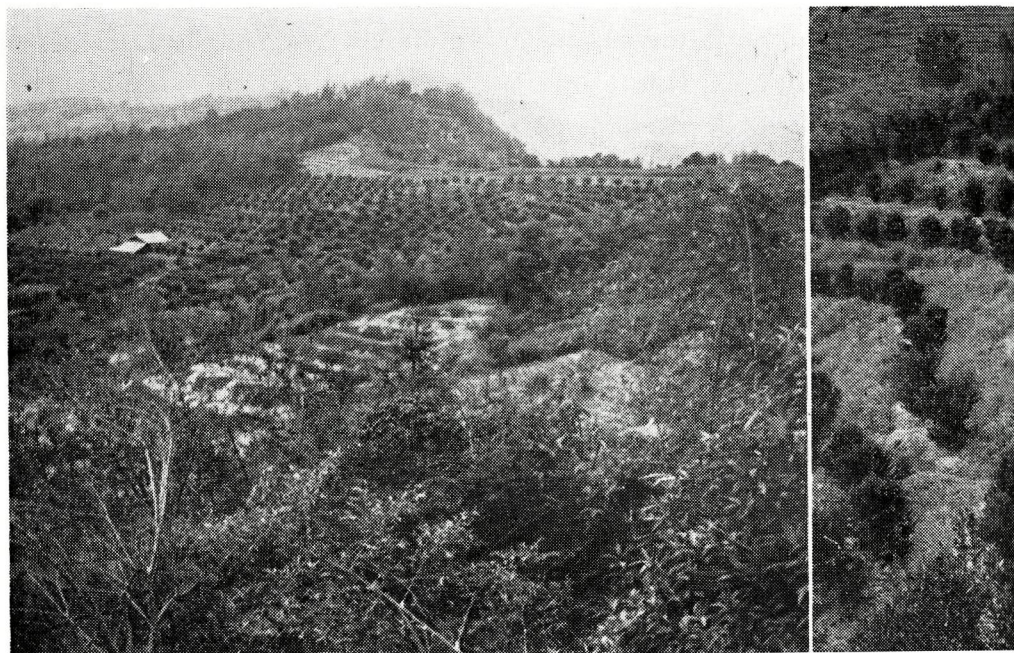
TOPOGRAPHY OF CITRUS GROVES IN TAIWAN



Most orange groves located at the hill-foot adjacent to rice field

Young orange trees on gentle slope in Miaoli Prefecture ▲

Orange groves in Tungshih area on slope land with an area over one hectare in size



Contour planting of orange trees, a common practice in Hsinchu area



A bird's eye view of the newly planted young orange trees on contour line



Another view of the newly established orange grove in Hsinchu area



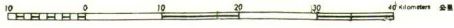
台湾土壤概图

GENERALIZED SOIL MAP OF TAIWAN

中華民國四十七年
1958

比例尺： 一百萬分一

SCALE: 1:1,000,000



台灣省農業試驗所印行

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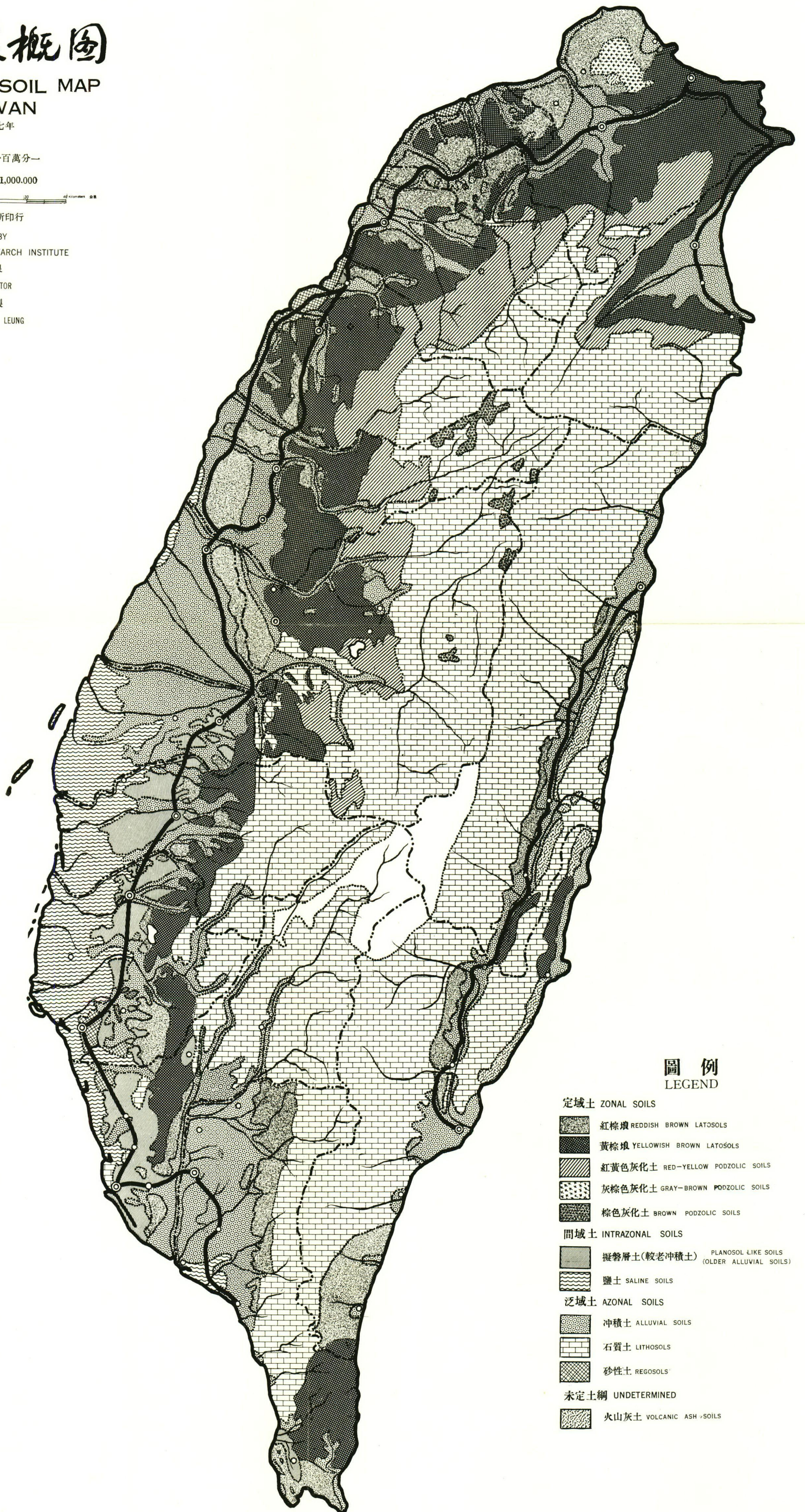
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PREPARED BY K.W. LEUNG



圖例 LEGEND

定域土 ZONAL SOILS

- 紅棕壤 REDDISH BROWN LATOSOLS
- 黃棕壤 YELLOWISH BROWN LATOSOLS
- 紅黃色灰化土 RED-YELLOW PODZOLIC SOILS
- 灰棕色灰化土 GRAY-BROWN PODZOLIC SOILS
- 棕色灰化土 BROWN PODZOLIC SOILS

間域土 INTRAZONAL SOILS

- 擬磐層土(較老沖積土) PLANOSOL LIKE SOILS (OLDER ALLUVIAL SOILS)
- 鹽土 SALINE SOILS

泛域土 AZONAL SOILS

- 沖積土 ALLUVIAL SOILS
- 石質土 LITHOSOLS
- 砂性土 REGOSOLS

未定土綱 UNDETERMINED

- 火山灰土 VOLCANIC ASH SOILS

G. Propagation (Rootstock, Nursery Practices and Selection of Propagation Material)

Rootstock and nursery practices: *Citrus sunki* is extensively used as rootstock for Tonkan, Ponkan, sweet oranges. *Poncirus trifoliata* is used as rootstock only for satsuma orange propagation, while no rootstock is used in the multiplication of pummelo for which air-layering is commonly employed.

Seeds of sunki are obtained from properly matured fruits and sowed immediately for good germination. After one year's growth in the bed, the sunki seedlings are set in the nursery with tape root removed. Grafting is practised after one year of growth in the nursery. Scionwood with at least two buds is used in cut-grafting and the top of sunki seedling is removed before cut-grafting which is usually done in February. In the past leaves of *Langus densespicata* (月桃葉) were used as wrapping material and muddy paste was used to cover the graftage. These practices are no longer used by nurserymen in Taiwan, instead, plastic sheets cut into strips and plastic tubes are generally used for protecting the graftage. By applying these new materials, a higher percentage of taking has been experienced by most of the nurserymen. It is believed that less mold infection will occur when plastic strips and tubes are used.

Poncirus trifoliata is recently used as rootstock for the propagation of satsuma orange in northern Taiwan.

It is generally believed that a proper rootstock for each species and variety would be very desirable. However, due to the lack of study in the field, information on rootstock is still scanty in Taiwan today.

Selection of propagation materials: In the past, the propagation materials needed by the nurserymen were usually taken from their neighbors or relatives free of charge. Nurserymen paid no particular attention to the source of budwood supply nor the quality and performance of the mother-

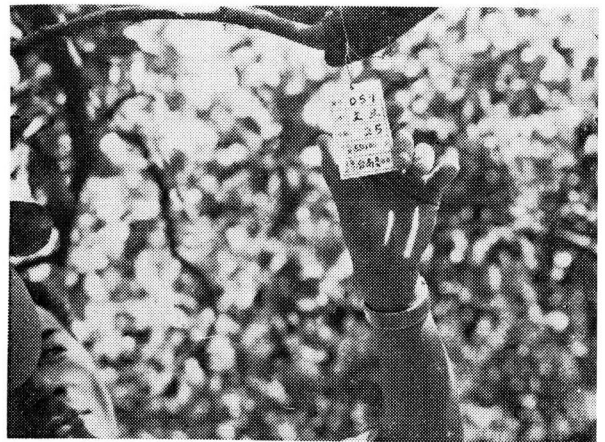
tree. A program of mother-tree selection of Ponkan, Tonkan and Sikan was started in 1951 by citrus workers at the various agricultural stations concerned and a number of mother-trees of good performance had been selected. Nurserymen were then urged to collect their budwood sticks from the selected mother-trees for the propagation of quality nursery trees. At least, a total of 2,000 mother-trees have been registered by the Provincial Department of Agriculture & Forestry (PDAF). Re-selection and additional registration of new trees are currently being carried out by PDAF and its subordinate stations. The criteria for the mother-tree for each kind of orange have been carefully specified by our citrus workers and may be briefly listed as follows:

1. At least over 10 years of age.
2. Free from insect and disease infestation.
3. Must be fruitful.
4. Bearing quality fruits.
5. True to varietal characteristics.



Selected mother-tree tagged with specified label

Air-layering employed ▶ in multiplying pummelo, plastic sheet used as a wrapping material



▲ Close-up of the tag indicating variety serial number, date of selection made and the area of the tree located



PROPAGATION

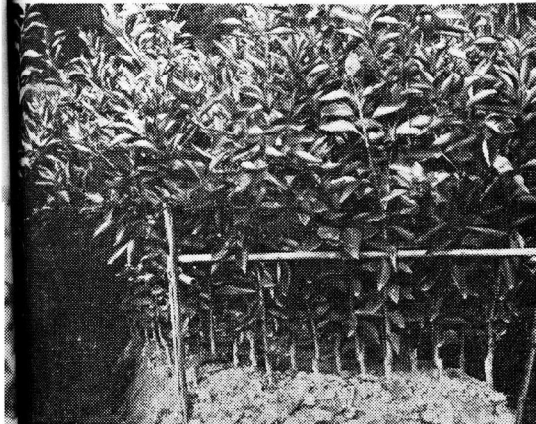


Another view of air-layering,
 ◀ rice-straws used as wrapping
 material instead of plastic sheet

12. A well managed citrus nursery
 observed in Chiayi area



Rangpur lime *Citrus*
limonia, Osbeck (or
 Canton lemon) left,
 ◀ and trifoliata orange
 (*Poncirus trifoliata*,
 Rafin), right, recent-
 ly used as rootstock
 by few nurserymen



General view of a citrus nursery
 certified by prefectural government

Hand operated weeding in a citrus
 nursery in Taichung area



H. Planting

Since most of the citrus groves are maintained by the farmers as a part of their diversified farming system, specialized citrus farming is therefore rarely adopted in Taiwan today, and consequently the size of the groves is small and all the practices are performed by hand. Machine operation is not yet known to citrus growers.

Nursery trees with one-year old top and three-year old rootstocks are set in the grove in January and February of the year. Before the nursery trees are delivered, planting holes are dug at least 1—2 months in advance and filled with well-decomposed compost as a source of organic matter. While planting, the surface soil is thoroughly mixed with the compost before the roots are carefully set into the planting hole.

The range of planting distances for the main citrus crops as adopted by the farmers are generally as follows:

<u>Crop</u>	<u>Distance (m.)</u>
Ponkan and Tonkan	3 x 3 to 4 x 4
Pummelo	5 x 5 to 6 x 6
Sweet orange	4 x 4 to 6 x 6
Satsuma orange	3 x 3 to 4 x 4
Kumquat	2.5 x 2.5 to 3 x 3

At such spacing, the trees are actually too close together to attain a full development. This is probably why the average longevity of citrus trees in Taiwan (about 30—40 years) is shorter than those grown elsewhere and the yield per tree is also much lower than that in other countries. However, farmers are of the opinion that trees planted closer together could withstand wind better under Taiwan conditions. This is a point which needs further study.

I. Fertilization

Kinds of fertilizers applied: Although the kinds of fertilizers applied vary with the locations of the citrus groves and the age of fruit trees, they may still be grouped as follows:

	<u>Pure chemical source</u>	<u>Organic source</u>
Nitrogen	Ammonia sulfate Urea	Soybean cake, peanut cake Compost, barn manure, green manure (Lupine, soybean)
Phosphorus	Calcium superphosphate	Bone meal, fish meal, rice barn
Potash	Potassium sulfate Potassium chloride	Ashes

Time, method and amount of application: The time of application varies from two times to three times a year depending on the conditions of the farmers. When two applications are practised in a year, January and June are suitable seasons and the fertilizers are equally divided for application, when fertilizers are applied three times a year, the time and amount may be tabulated as follows:

<u>Time of application</u>	<u>Relative amount of fertilizer (%)</u>		
	<u>Nitrogen</u>	<u>Phosphours</u>	<u>Potash</u>
January	60	50	40
May	20	30	40
November	20	20	20

The method of application varies with the kind of fertilizer, though trench and ring applications are most commonly used. Broadcasting is rarely used for citrus grove in Taiwan. Even today, the standard rates of fertilizer application for citrus groves in Taiwan are not yet well established; nor has the soil fertility of the citrus groves been carefully studied.

Sediments collected from drainage trenches right in the field are also used as manure for supplying organic matter and minerals to trees and this

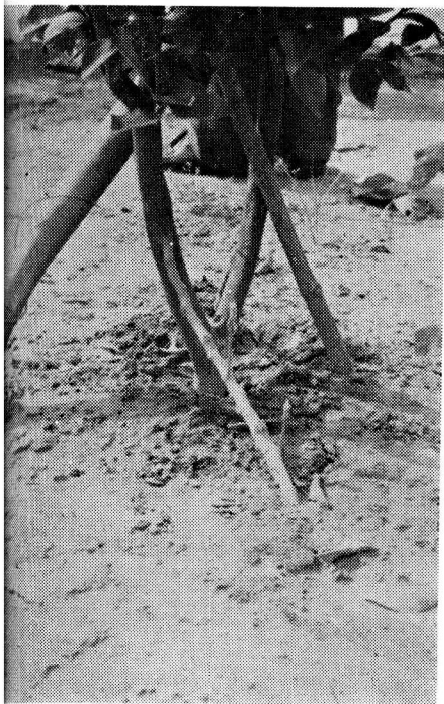
practice is commonly employed by growers in the plain areas. In early spring or immediately after harvesting, barn manure and compost are applied at a rate of 20 -30 kg. per trees or 12—18 M.T. per hectare.

Lupine (*Lupinus luteus*) has been introduced to farmers as a green manure crop for citrus groves, but the acreage is still limited due mainly to the harvesting operation handicapped by the growing of green manure crop. Although citrus farmers are experienced in applying compost and barn manures, they are also beginning to learn the benefit of green manure crops and the importance of balanced chemical fertilizer application.

Recommended Amount of Fertilizers for
Tonkan (*Citrus tankan*) groves⁹

Age of tree (year)	Ammonium sulfate (N 21%)	Calcium superphosphate (P ₂ O ₅ 18%)	Potassium sulfate (K ₂ O 50%)
1	240	270	70
3	320	360	110
5	640	800	350
7	970	1,150	450
9	1,120	1,420	560
11	1,320	1,600	630
13	1,520	1,780	700
15	1,680	1,870	730
17	1,840	2,050	800
19	2,000	2,220	870
Above 21	2,160	2,400	940

When sweet orange trees are fertilized, 25% more of the fertilizer needed.



In arching employed in rejuvenating the root of a grown tree

ORCHARD MANAGEMENT



Hand-operated sprayer used in plant protection in Tungshih area

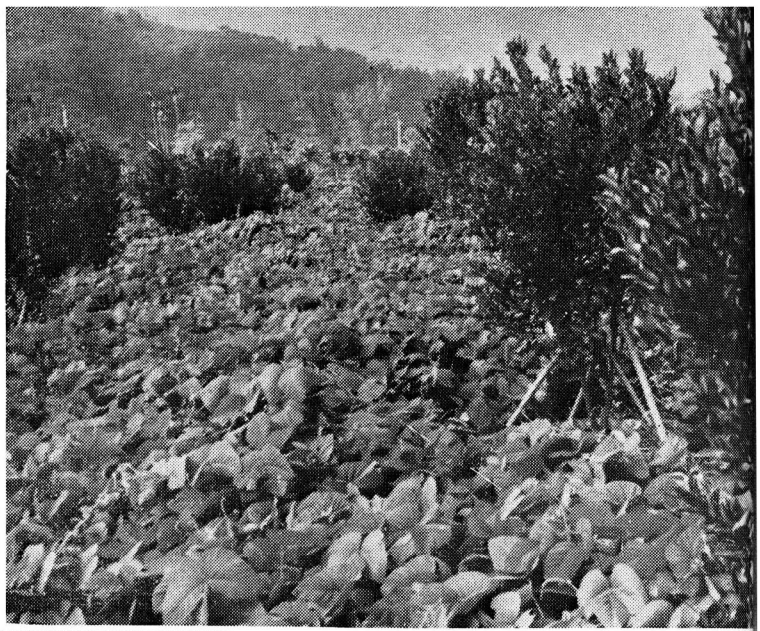


Shallow ditch made ready for application of farm manure



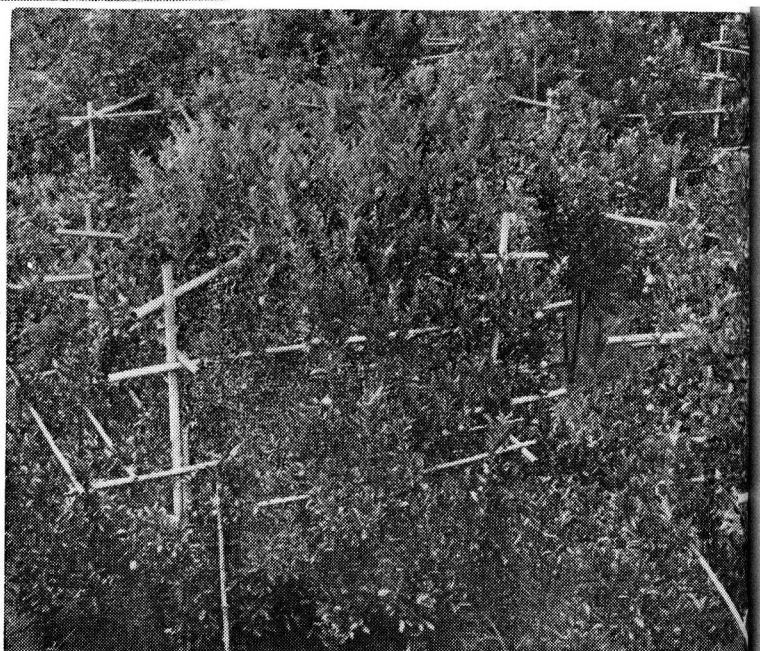
Ditch filled with well decomposed animal manure, before covered with soil, commonly applied in southern Taiwan

Tiger-paw bean (*Mucuna capitata*, Wight) grown in the young orange grove serving as a cover crop during summer



Bamboo poles (*Bambusa* spp.) extensively used to support the branches heavily loaded with bumper crop

22. Another way of preventing branch damage and fruit loss by using bamboo poles to support the barnches in all directions



J. Cultivation and Orchard Management

Management of citrus groves varies from moderate intercropping to heavily multiple mixed-planting. Farmers take citriculture as a part of their diversified farming system and it is true in the way of managing the citrus groves. Groves intensively intercropped with sweet potato, guava, taro, pepper and other vegetable crops can commonly be seen in central Taiwan. On the east coast, pineapple is another helpful crop to support the young orange groves before the latter reach the bearing stage. When carefully intercropped, the production of both kinds of crops is mutually benefited due possibly to the frequent weeding practices and additional fertilizers applied. However, no intercropping is found in the aged groves where no room is available for other crops due to the small planting distance. Groves under intensive intercropping are kept free from weeds and well tilled throughout the year. All the weeding and tillage operations are performed entirely by hand with the aid of simple farm implements. Weeding or tillage is usually made in early spring and late fall and surface soils are not disturbed during the summer months because of the typhoon season. Any disturbance of the surface soil during the typhoon season would cause serious soil and water erosion.

Because of ample rainfall, citrus groves in Taiwan require no or little irrigation during the most part of the year. Instead, good drainage is needed in most groves especially those on the plain. Drainage ditches are made at the time of land preparation for planting. Drainage ditches on hillside are also used as a step way of a grove.

Cover crop could casually be found in citrus groves in Taiwan today because every piece of land is intensively and wisely used. On account of unavailability of direct cash return from the cover crops, farmers have usually given up the planting of cover crops in their citrus groves. As to green manure crops, lupine was once introduced but found in conflict with the harvesting operation, as lupine usually reached its full plant development in December-February in the winter exactly during the harvesting season of

oranges. The harvesting operation is somehow handicapped by the green manure crop in the field.

Pruning and rejuvenation are occasionally employed in the established citrus groves. Light pruning is usually made to this evergreen tree crop. Pruning for rejuvenation purpose has been tried and the results have turned out to be satisfactory.

Mounding of deposits collected from drainage ditches is another management practice adopted by the growers in Hsinchu area. Mounding is considered to be very worthwhile by the growers on account of its supply of nutrients and its capacity to strengthen of roots and trunk against strong wind. It may be partly true but this practice seriously reduces the function of rootstock when the trunk is deeply mounded and new roots produced right from the trunk.

All farmers in Taiwan are well aware of the destructiveness of typhoons and windbreaks are universally employed as a means of protection in growing citrus crops. Since the size of a citrus grove is usually rather small, being only about 0.1–0.5 ha., it is easy to protect the grove from wind damage by planting windbreaks around it to serve as a fence. It is especially true on the plain. The plant used most commonly for windbreak purpose is bamboo (*Bambusa* spp.) for its height which provides safe protection to the fruit trees and for its seasonal supply of edible bamboo sprouts, fuel material and bamboo poles for general uses. Acacia (*Acacia confusa*) is also planted for windbreak purpose in some areas for its quick growth and fuel value.

Fruit and flower thinning are practised especially on young orange trees in order to promote the tree growth at the young stage. All kinds of thinning are performed by hand labor during and after the flower blooming.



Taro (*Colocasia antiquorum*, Schott), a kind of vegetable interplanted in the young orange grove

COMPANION CROPS

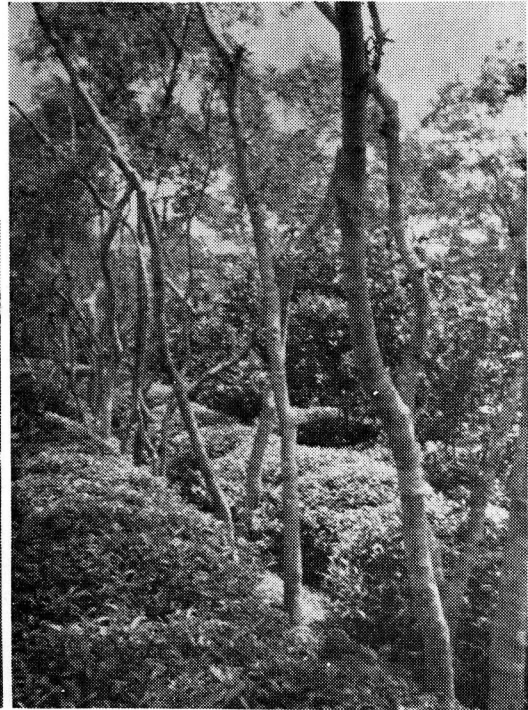
Tea (*Thea formosensis*, Masam, and *Thea sinensis*, L.), one of the most important beverage crop of the world, occasionally a companion crop of citrus fruit seen in Taiwan



Banana (*Musa sapientum*, L.),
also one of several companion
crops of citrus fruits



Acacia confusa Merr serving
as windbreak, shading tree and
also a companion crop of
orange tree



Betel palm (*Areca catechu*, L.),
a companion crop of citrus fruit
trees

Pineapple (*Ananas comosus*, Merr)
and litch (*Nephelium litchi*, Combess),
most common crops found in the
orange groves in Taiwan



K. Plant Protection

In the early post-war years, it was found that citrus groves in Taiwan were generally infested with injurious insects and diseases due to war-time negligence in plant protection and the lack of pesticides and equipment at that time, thus inflicting heavy losses to the farmers. The warm and humid climate of Taiwan is inductive to the development of insects and diseases injurious to plant growth and fruit growing. The poor ventilation and high humidity in the groves as a result of close spacing of the trees and intensive intercropping further aggravate the situation. Farmers are now being urged to widen the tree spacing in their groves, but the changes will be slow and can be brought about only gradually through means of education and demonstration.

The most common and important insects and diseases which attack the citrus trees and fruits in Taiwan are as follows¹⁰:

Insects:

Citrus spiny white fly	<i>Aleurocanthus spiniferus</i> Quaintance
Root trunk borer	<i>Anoplophora maculata</i> Thomson
Green scale	<i>Coccus viridis</i> Green
Oriental fruit fly	<i>Dacus dorsalis</i> Hendel
Citrus jumping plant lice	<i>Diaphorina citri</i> Kuwayama
Cotton cushion scale	<i>Icerya purchasi</i> Maskell
Mealy bug	<i>Nipaecoccus filamentosus</i> Cockerell
Fruit piercing moth	<i>Othreis (Ophideres) tyrannus</i> Quenee
Citrus red mite	<i>Panonychus citri</i> McGregor
Black armored scale (Citrus parlatoria)	<i>Parlatoria zizyphus</i> Lucas
Leaf miner	<i>Phyllocnistis citrella</i> Stainton
Citrus rust mite	<i>Phyllocoptes oleivorus</i> Ashmead
Citrus dog	<i>Princeps democleus</i> Linnaeus, <i>libanius</i> Fruhstorfer
Citrus stink bug	<i>Rhynchocoris humeralis</i> Thunberg
Citrus aphid	<i>Toxoptera citricidus</i> Kirkaldy

Diseases:

Diplodia rot	<i>Diplodia natalensis</i> Pole-Evans
Citrus scab	<i>Elsinoe fawcetti</i> (Jenk) Bitancourt et Jenkins
Citrus black spot	<i>Guignardia citricarpa</i> (McAlp) Kiely
Foot rot and gummosis	<i>Phytophthora</i> spp. <i>Rhizoctonia</i> sp.
Tristeza virus	Stem pitting and seedling yellows virus
Citrus canker	<i>Xanthomonas citri</i> (Hasse) Dowson

Citrus plant protection has been improved since 1951 as series of projects supplying pesticides and spray equipment have been constantly undertaken by various government organizations (PDAF, TARI), Fruit Marketing Cooperatives, Farmers' Associations and JCRR. As a result of such efforts, better crops are produced from the clean and healthy trees; and growers have been gradually educated to assume to insect/disease control work in a self-confident manner.

The pesticides commonly used in Taiwan today are as follows:

- Fungicides : Bordeaux mixture, captan, lime sulfur, Phaltan, wettable sulfur, Tuzet, zineb
- Insecticides : Dieldrin, Dimecron, dimethoate, Ekatin, Folithion, Gusathion, malathion, menazon, metasystox(i), parathion, sevin, summer oil
- Acaricides : Chlorobenzilate, kelthane, Tedion
- Attractants : Eugenol, protein hyarolysate

L. Harvesting, Grading and Packing

Harvesting: Because the size of citrus groves in Taiwan is usually small, and most of the groves are widely scattered instead of being concentrated in several general areas, there is no need for "professional picking crew" at the present time. With very few exceptions, the majority of growers pick their citrus fruits themselves with family labor. In the past picking was done by inexperienced family labor; and, as many growers did not know the techniques and importance of picking, this operation was usually accomplished in a rather crude manner. Citrus fruits were pulled from the branches and, as a consequence, many of the fruit stalks and rinds were injured and broken. Fruits were also bruised when they were poured from one container to another for transportation from groves to farmsteads. Therefore, a demonstration program for teaching the growers the improved way of picking by using citrus fruit clippers, soft picking sacs and field boxes, initiated by the author, was conducted jointly by PDAF, JCRR and the Fruit Marketing Cooperatives concerned in various citrus producing areas in early 1950s. At present, workers of the Fruit Marketing Cooperatives and leaders of citrus growers have been convinced of the importance of proper picking technique and equipment. Now pickers of the family are urged to adopt the improved harvesting technique and equipment. Consequently the degree of bruise and damage has been greatly reduced.

After picking, fruits are packed into wooden boxes or baskets lined with soft paper or cloth and are hauled by trucks, bicycles or other animal, man and machine-driven facilities, varying with the availability of such facilities at different places. Most growers send their fruits to the nearby marketing center or cooperative packing house by family labor and some growers sell the whole crop directly to the fruit dealers when their groves are in remote valleys and their groves are over one hectare in size.

Grading and packing: The fruit grade is determined in accordance with the size and the quality of the fruit. The size is graded by the fruit circumference while the quality is measured by the maturity, cleanliness, shape, appearance, etc. The different grades of fruit size of four citrus

fruits currently used may be tabulated as follows:

Grade	Circumference (cm.)			
	Ponkan	Tonkan	Tou-you	Wentan
1st	above 25	22	50	35
2nd	above 23	20	45	30
3rd	above 20	18	40	25
4th	above 17	—	—	—
Cull	below 17	below 18	below 40	below 25

The grading of sizes of Tonkan is done by machine sizer while the grading of Ponkan and pummelo, due to their fruit shape, is performed simply by hand with the aid of fruit ring provided by the Bureau of Commodity Inspection & Quarantine. Grading is usually done at the packing ground operated by the Fruit Marketing Cooperative of the production center.

Fruits for domestic marketing are usually graded and packed by fruit dealers in the production centers. Those for export are completely graded and packed by the concerned Fruit Marketing Cooperatives in each producing center. Only wooden cases with official specifications are permitted to be used as orange container for export trade. The holding capacity of the wooden crates varies with the demand of the importers abroad. For instance, 30—kg. crates are exclusively used for shipment to Manila, 20—kg. ones for Singapore and 9—lb. ones for Canada importers.

All Ponkan and Tonkan fruits are waxed and graded before wrapping. The graded lots will remain in the packing house for 24 hours before they are wrapped and packed into the wooden crates, thus enabling the packer to sort out any oranges becoming molded before packing.

M. Inspection and Marketing

The Bureau of Commodity Inspection & Quarantine is in charge of the inspection of citrus fruits for export. Citrus fruits for home consumption are not inspected. Inspections are made at both the packing houses in the collection centers and the port of export.

Upon receipt of application for inspection by the exporters, the Bureau or its branch offices will dispatch inspectors to the packing houses to make inspections. If the quality and grade of the shipment inspected meet with the specified standard and the approval of the inspectors, certificates will be issued to the exporters by the inspectors. Random sampling for inspection at the port of export is also practised by the said Bureau. This type of inspection will serve to protect the shipper as well as the importers abroad.

Fruits consumed locally are entirely marketed through the channel of the fruit dealers and retailers. Fruits for export trade are marketed jointly by the Fruit Marketing Cooperatives and exporters. At present, 50% of the total citrus fruits for export are handled by Fruit Marketing Cooperatives independently and the balance is marketed by the exporters. The profits thus gained are returned to the fruit growers in forms of education, extension and further development of citrus production through research.

According to the past record on hand, the production as well as the marketing of citrus fruits in Taiwan were not very steady. The proportion of fruits for home consumption and export trade also fluctuated from year to year, a situation due possibly to changing political influence and the trade policy of the government.

N. Production in Recent Years

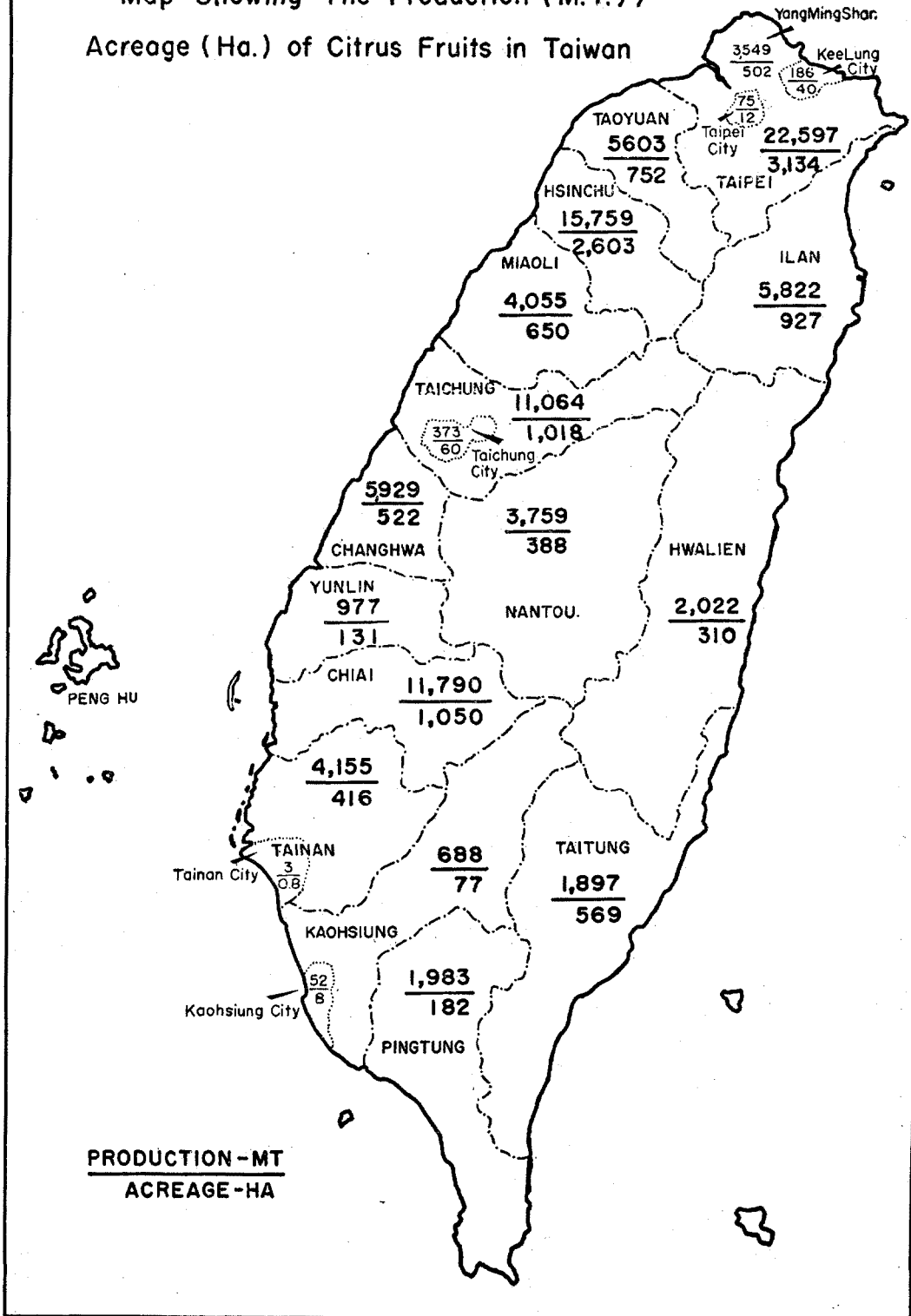
Increased production of citrus fruits is as shown below:

	<u>Harvested acreage</u>	<u>Total production</u>
	(ha.)	(MT)
Pre-war peak ¹¹	5,516 (1942)	38,745 (1941)
1945	3,583	16,877
1950	4,661	28,284
1955	5,246	30,235
1960	8,098	52,866
1961	9,032	54,927
1962	10,245	67,140
1963	11,291	78,680
1964	13,361	102,341

Acreage & Production of Principal Citrus Fruits (1963/64)¹¹

	<u>Acreage</u>		<u>Production</u>	
	<u>ha.</u>	<u>%</u>	<u>MT</u>	<u>%</u>
Ponkan	4,525	33.87	40,474	39.55
Tonkan	6,399	47.89	43,408	42.41
Satsuma	22	0.17	138	0.14
Sweet orange	964	7.22	5,166	5.05
Pummelo	911	6.81	8,699	8.50
Others	540	4.04	4,456	4.35

Map Showing The Production (M.T.) /
Acreage (Ha.) of Citrus Fruits in Taiwan



O. JCRR Assistance Rendered to the Improvement of Citrus Production in Taiwan

In the past decade, citrus farmers of Taiwan have learned the advantages of growing sweet oranges which mature later, have better shipping and keeping quality and thus command a higher price on the local market than the loose-skin types after the season of the latter is over. Demand for sweet orange nursery trees was mounting during 1950—1960. JCRR gave both financial and technical assistance to the Taitung District Agricultural Improvement Station and the Taichung Fruit Marketing Cooperative for the propagation of quality sweet orange nursery trees.

In order to propagate nursery trees of good quality by supplying scionwood sticks from good and fruitful mother-trees of known origins, the said agencies, assisted by a number of horticultural workers, conducted a mother-tree survey of the sweet oranges grown in Taiwan before the multiplication work was started.

As a result of this survey, it was found that sweet orange varieties grown in Taiwan in the past have become quite mixed, affecting both the quality and the yield of the tree. In view of this, JCRR assisted the National Taiwan University and the Hsinchu Fruit Marketing Cooperative to carry out a program of introducing new varieties from abroad with the aim of developing the sweet orange production in Taiwan. A total of 177 budwood sticks belonging to 9 varieties (i. e. Parson Brown, Jaffa, Avon Everbearing, Lue Gim Gong, Drake Star, Pineapple, Dream Navel, Orlando Tangelo and Nucellar Minneola Tangelo) were introduced into Taiwan in 1953 directly from the Grand Island Nursery at Eustis, Florida, U. S. A. Seedless Valencia and Ruby grapefruit were also introduced in 1956 from Armstrong Nursery in California, U. S. A. At this moment, Lue Gim Gong and Pineapple are getting popular in central Taiwan.

With the aim of minimizing the spoilage and loss during storage and transit, JCRR assisted technically and financially the Provincial Department

of Agriculture & Forestry to conduct a demonstration of the proper handling of oranges. The proper methods of picking, sorting, packing and equipment needed in handling oranges were also demonstrated to farmers.

JCRR also exerted great effort in helping the citrus growers to control the insects and diseases. Training classes on the control techniques held for citrus growers, developing of the manufacture of pesticides and spray equipment and strengthening of pest control researches are the highlights of programs successfully implemented by fruit growers, fruit cooperatives, prefectural governments, Taiwan Agricultural Research Institute, National Taiwan University, Taiwan Provincial Department of Agriculture & Forestry, etc. Farmers are now gratified to acknowledge that their groves are better looking and their fruits are better both in appearance and in quality than some ten years ago.

SWEET ORANGE DEVELOPMENT PROJECT IN EASTERN TAIWAN

C. L. Luh

Sr. Specialist, Plant Industry Division

Chinese-American Joint Commission on Rural Reconstruction

(Excerpt from PID-C-104, March 15, 1961)

1. Project Implementation:

a. Background—The east coast of Taiwan is usually considered as the under-developed section of the Island and people in that area are financially unable to develop anything of their own. Since the growing of sweet orange in that area was found very promising with respect to the climatic and soil conditions there, farmers in the Taitung area were encouraged to grow the sweet orange by receiving planting materials as loan in kind from the Taitung District Agricultural Improvement Station through the Taitung Hsien Government. The recipient growers are required to pay back the fixed costs to the station three years after receiving the young trees.

b. Extension area — The extension of young sweet orange trees in Taitung Hsien is limited to two selected areas with the hope that a concentrated planting of a new fruit crop in designated areas would facilitate the extension and marketing activities.

c. Procedure—Individual farmer in these two selected areas in Taitung Hsien wishing to grow the sweet orange may submit his application, stating the site of his grove and number of young trees needed, to the Hsien Government. The Hsien Government and Agricultural Improvement Station will examine the personality of the applicant and also the topography of the proposed grove site. If approved, the applicant will be advised to prepare the land in accordance with the soil conservation measures, to grow a crop of green manure in the spring and plow under in the autumn, then to have the planting holes dug spaced properly according to the given instruction. If the applicant fails to fulfill any of the requirements mentioned

above, then no fruit trees will be released to him. A contract is signed between the grower and the Hsien Government, plus one guarantor to take the full responsibility of repaying the loan when the recipient farmers fails to do so. The money thus collected will be used for the multiplication of another lot of young fruit trees for other farmers in the area. In case an individual farmer of a certain village fails to pay back the tree cost to the station upon expiration of the 3-year period, then further loan in kind to the whole village will be withheld until the village forces him to clear the account. There has been instance that a whole village paid the tree cost for one individual farmer in order to have their further applications considered by the authority concerned.

2. Grove management:

Each orange grower is asked to join the pest control team from which modern control techniques are disseminated and dependable pesticides at reasonable prices are obtained through government channels. The pest control team is under the constant supervision of the Taiwan Provincial Department of Agriculture & Forestry. Improved cultural practices are publicized through training courses and demonstrations in the field.

3. Present Status of development:

From 1953 till the end of December 1958, a total of 62,173 young sweet orange trees have been distributed to farmers. The varieties distributed consisted of Valencia Late and Sikan. The planting and fruiting areas as of January 1961 are tabulated as follows:

No. of farm households receiving tree loan	No. of trees extended	Area planted (ha.)	No. of bearing trees	Area of bearing trees (ha.)
304	62,173	205	25,057	113

The multiplication of young trees is handled by the Taitung District Agricultural Improvement station. With three sets of multiplication funds, the said station is capable of multiplying a considerable amount of young trees every year at the present time.

The plantings made in early 1952 and 1953 have reached the bearing stage; and, though with limited quantities, the growers have been enjoying their harvests and gratifying economic returns. The bumper fruit harvests in the few early groves certainly stimulated the interest of the other farmers in the same area. Consequently, more applications have been received by the Hsien Government and more trees is needed to meet the expanding demand. It is expected that more production of sweet orange will be put onto the local market in the near future.

4. Problems encountered:

The Taitung District Agricultural Improvement Station is not a revenue-producing organization and the personnel there is limited, therefore, the number of young trees propagated every year could hardly keep pace with the increasing demand. In another words, the said station is technically sound but weak in handling the multiplication work. Commercial nurserymen are encouraged to undertake the multiplication work, and arrangement is being considered among parties concerned.

甜橙母樹選種調查表

編號	區	種第	號	園主姓名				
甲	果園：				北 ↑ 西←→東 ↓ 南			
	一、地址—							
	二、地勢—		三、土質—					
乙	母樹：				22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1			
	一、品種—		二、來源—					
	三、根砧—		四、位置 行 株					
	五、樹齡—		六、樹幹高度 公分					
	七、蟲害—		八、病害—					
	九、生長性狀：		1951年	1952年		1953年	1954年	1955年
	(一) 樹冠高 (m.)							
	(二) 樹冠寬 (m.)							
(三) 結果量 (kg.)								
(四) 枝葉疏密								
(五) 葉色深淺								
(六) 樹勢強弱								
丙	果實性狀：		1951年	1952年	1953年	1954年	1955年	
	一、果實高 (cm.)							
	二、果實寬 (cm.)							
	三、果實重 (gm.)							
	四、果皮色澤							
	五、果皮厚 (mm.)							
	六、油包大小							
	七、果囊數—是否整齊							
	八、囊皮厚薄							
	九、果心大小							
	十、種子數量							

果樹位置之記載及標誌方法

在一果園中，於選定一優良母樹後，應記載其在果園中之位置。記載前須將整個果園之果樹，分為南北行與東西列，將至南向北及自西向東一直線上之各樹依次編號。於記載所選定優良母數之位置時，即可依照其在南北行中屬於第幾行，東西列上屬於第幾株；故其確實位置即為南北 X × 東西 Y。再每次選定優良母樹後，應先給以選定編號，然後在距地一尺五寸之樹幹上用白漆畫一圓圈，以作將來複查時之標誌。

丁	果實品質：	1951年	1952年	1953年	1954年	1955年
	一、果 肉 色 澤					
	二、果汁數量 (c.c.)					
	三、果汁重量 (gm.)					
	四、果汁糖度 (Brix)					
	五、果汁酸度 (‰)					
	六、果汁風味 (上、中、下)					
	七、採收及分析日期					
	八、採收起造日期					

戊	調查結果：	1951年	1952年	1953年	1954年	1956年
	一、選定接穗數					
	二、選取果實數					
	三、選定理由	樹勢30%				
		產量30%				
		品質40%				
	四、採取接穗日期					
	五、接穗價格 $\frac{\text{元}}{100\text{枝}}$ $\frac{\text{三}}{\text{枝}}$					
	六、果實價格 $\frac{\text{元}}{\text{公斤}}$					
	七、果 農 意 見					
	八、調 查 日 期					
	九、調 查 人 姓 名					

附	甜橙母樹選種標準：	
一、	樹齡——凡樹齡達三十年以上之橘樹不宜採用。	
二、	產量——每樹必須產果達百枚以上，否則不宜選取。	
三、	果實：	
	(一) 果樹及果寬 6-7cm.	(二) 果 重 150-200gm.
	(三) 果皮厚度 2-4mm.	(四) 種子粒數 0-10粒
	(五) 果 實 數 10-12個	(六) 果汁數量 80-100c.c.
	(七) 糖 度 10-15Brix	(八) 酸 度 0.8-1.2%

行政院農委會圖書室



0014552